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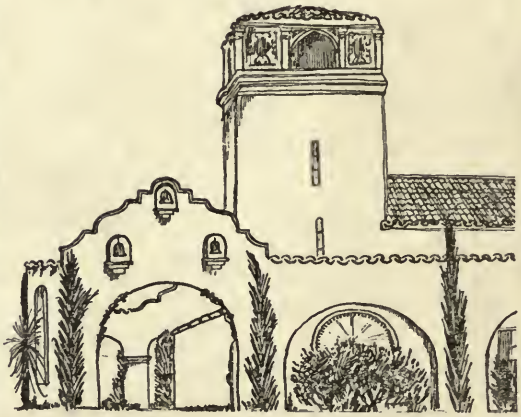

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TUBERCULOSIS

OF

BONES AND JOINTS.

BY

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THE AUTHOR

TAKES GREAT PLEASURE IN DEDICATING THIS VOLUME

TO HIS FRIENDS,

THE FELLOWS OF THE AMERICAN SURGICAL ASSOCIATION,

WHO HAVE CONTRIBUTED SO MUCH TOWARD THE ADVANCEMENT OF SURGERY IN THE UNITED STATES.

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PREFACE.

TUBERCULOSIS of bones and joints is such a common affection that a large percentage of the clinical material of the surgeon and the general practitioner is made up of such cases. The tubercular nature of most of the chronic affections of bones and joints is not as freely accepted and as fully realized as it should be by the mass of the profession, and consequently a correct diagnosis is often not made before the disease has become incurable. The successful treatment of these affections depends largely on an early, correct diagnosis and the adoption of a timely, rational, local, and general treatment in consonance with the true nature of the disease. The object of the author in writing this book has been to collect from recent literature the modern ideas on tubercular disease of bones and joints and present them to the reader in a condensed form, mingled, in appropriate places, with the results of his own experience. Old authorities are occasionally quoted for the purpose of showing the contrast between the old and recent views regarding the etiology and nature of this form of bone and joint disease. My thanks are due to Dr. Stehman for correcting the galley-proofs, and to Mr. Rettig for a number of original drawings. If this work should become useful in alleviating one of the most common ailments of the poor, and add something toward the advancement of the surgery of the bones and joints, the hope and ambition of its author will be realized.

N. SENN.

CHICAGO, September 1, 1892.

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Tuberculosis of Bones and Joints.

CHAPTER I.

History.

The history of tubercular affections of bones and joints is quite an interesting one, as the early part of it gives an account of the crudest ideas in reference to the etiology, pathology, and treatment of these affections; while that part which covers the last decade bristles with new revelations and startling discoveries, based on accurate clinical observation, microscopical examination, bacteriological investigation, and experimental research. No department in medicine or surgery has witnessed a more radical change than the etiology of tuberculosis of bones and joints. During the time of Hippocrates some general facts were understood, such as that phthisis develops more or less directly after certain surgical accidents or diseases; but nothing definite was known. Less than a century ago, we find chronic inflammatory affections of bone designated by such vague terms as *spina ventosa*, *osteophthoria*, *osteospongiosis* (Lobstein), and *pædarthrocace* (Severin). J. L. Petit did not know under what head he should classify these affections. He was in serious doubt whether they should be classified with exostosis, softening of bone, caries, atrophy, necrosis, or whether they formed a separate group of bone-lesions, which should be brought under a distinct head. Tuberculosis of bone, as we now understand it, was described by Boerhave as a destructive process in the epiphyses, extending from within outward. A. G. Richter, Böttcher, and Hebenstreit regarded it as a caries commencing in the interior of the medullary canal. Augustin defined it as an inflammatory process in the interior of bone, which, in its course, brought about complete textural changes

of the parts affected. Voigtel looked upon it as a hypertrophic process, in some cases; in others, as a softening of the tissues, leading to perforation externally. Boyer gave no definite opinion regarding the nature of the disease. Béclard thought that it consisted of an active proliferation of the endosteum. Otto regarded it as an internal, central caries, with expansion and softening of the bone, accompanied sometimes by the formation of osteophytes. Astley Cooper described it as a spongy exostosis. Ph. v. Walther maintained that it is produced by the formation of a steatoma in the medullary tissue. Lobstein recognized a total, central, cortical, and epicortical spina ventosa.

The first accurate clinical picture of a tubercular joint was drawn by Wiseman (several chirurgical treatises, London, 1676). He applied to this affection the term *white swelling* (tumor albus), which, since his time, until recently, and, to a certain extent, even at the present time, has retained its place in surgical nomenclature. Under this term he grouped all joint-lesions characterized by chronic inflammation and enlargement of a joint, and maintained that, in the majority of cases, it is caused by scrofula. He was of the opinion that the disease may have its primary starting-point either in the soft tissues or the articular extremities of the bones composing the joint. Benjamin Bell ("On the Theory and Management of Ulcers, with a Dissertation on White Swelling of the Joints." Edinburgh, 1779) taught that a tumor albus may be caused by a trauma or a scrofulous or rheumatic inflammation. Later, Laennec, by a stroke of genius, and profiting by the previous labors of Bayle, demonstrated the unicity of the tubercular process and its various products,—phthisis, its granulations, gray tubercles, and caseous foci,—and that most of the lesions considered scrofulous were, in reality, tubercular in their nature. The fruits of this great discovery were soon realized in surgery. Delpech studied the subject in its surgical aspects. Michet wrote on tubercular ostitis; and Nélaton, in his classical treatise

on tubercular affections of bone, applied to the osseous structure the discovery of Laennec, and showed that in bone, as in other organs, *tubercle may appear either as a circumscribed or diffuse lesion, and that many chronic suppurative lesions in bone originated in tubercular foci.* Samuel Cooper ("A Treatise on Diseases of the Joints." London, 1807) called attention to the heredity of the scrofulous predisposition, and to the influence of traumatic lesions in exciting a local manifestation of the disease in persons so predisposed. Benjamin Brodie ("Pathological and Surgical Observations on the Diseases of the Joints." London, 1818) believed that tumor albus is caused by a chronic inflammation of the synovial membrane in joints of the same character as granular conjunctivitis. Rust ("Arthrokakologie." Wien, 1817) made a wide distinction between tumor albus proper and scrofulous inflammation of joints. Bonnet ("Traité des Maladies des Articulations." Paris, 1845) enumerated scrofula and tuberculosis as causes of the different forms of tumor albus. The first anatomical demonstration of the identity of the process in the synovial membrane in some cases of tumor albus, with tubercular lesions in the lung, was furnished by Rokitansky in 1844. A number of years later Virchow (Virchow's *Archiv*, B. iv, S. 312) pointed out that in the most intractable joint-lesions the disease is caused by miliary tuberculosis of the synovial membrane; and in 1865 Volkmann (*Krankheiten der Bewegungs organe Chirurgie*, von Pitha-Billroth, B. xi, S. 2. Erlangen, 1865) corroborated this statement by his own observations. The results obtained from the crude inoculation experiments, which were made by Villemin (1865–1869), pointed strongly toward the infectiousness of tuberculosis, and since that time diligent search was made to discover and isolate a specific micro-organism which should be characteristic of this disease. In 1869, Köster (Virchow's *Archiv*, B. xlviii) furnished convincing proof that miliary tubercles can be found in every fungous joint, and discovered and described the giant-cells which, until recently, have been regarded as the pathogno-

monic histological element of tubercle. Hueter (*Deutsche Zeitschrift f. Chirurgie*, B. xi, S. 317) and Schueller ("Experimentelle u. Histologische Untersuchungen," etc. Stuttgart, 1880) made interesting experiments to establish the microbic origin of tuberculosis, and their work led others to make investigations in the same direction.

Lanceraux, Coyne, and Labbé, in 1873, showed the similarity existing between the fungous masses in tubercular joints and in tendon-sheaths, and since that time the absolute identity of the two analogous conditions has been made clear by the labors of Trelat, Latteau, Terrier, and Vercherè. In 1879, Brissaud and Josias published the results of their investigations, establishing the tubercular nature of cold abscesses. In 1879, Lannelongue and Kiener made known their views concerning the identity of lesions in bone and joints that had heretofore been regarded as of a scrofulous nature, with well-recognized tubercular affections in other organs.

Volkmann, Billroth, and König made valuable clinical contributions which established the tubercular nature of strumous disease of bone and tumor albus long before the bacillus of tuberculosis was discovered. Great activity was displayed in all countries to establish the parasitic nature of tuberculosis.

Theories were advanced and discussed, microbes were found and described, which were supposed to bear a direct etiological relationship to tuberculosis, but nothing definite was known on the subject until Robert Koch, the father of bacteriology ("Die Ætiologie der Tuberculose." *Berl. klin. Wochenschrift*, 1882, No. 15), in 1882, announced to the profession his great discovery. He had found and demonstrated the true cause of tuberculosis, the *bacillus of tuberculosis*, and in his first publication brought such convincing proof of the correctness of his claim that, with few exceptions, it brought conviction even to the most skeptical. He had not only found the bacillus, but showed that it was constantly present in all tubercular lesions. He had isolated and cultivated the bacillus from

tubercular tissue, and finally he had furnished the crucial test, —had produced artificial tuberculosis in animals by inoculation which was identical with tuberculosis in man. He examined 19 cases of miliary tuberculosis, in which bacilli were found in every nodule; 29 cases of pulmonary phthisis, in every one of which bacilli were found, most numerous, with the exception of the sputum, in recent caseous foci and in the walls of cavities undergoing speedy destruction. He also found them constantly in tubercular ulcers of the tongue, tubercular pyelonephritis, and tuberculosis of the uterus and testicles; also, in 21 cases of tuberculosis of lymphatic glands. Further, in 13 cases of tuberculosis of joints, and in 10 cases of tuberculosis of bone; in 4 cases of lupus, in which only a single bacillus could be seen in the giant-cells; in 17 cases of *perlsucht* in cattle. Finally, in animals inoculated with tubercular virus: 273 guinea-pigs, 105 rabbits, 44 field mice, 28 white mice, 19 rats, 13 cats, besides dogs, chickens, pigeons, etc. A number of pathologists, who inoculated animals with non-tubercular material, claimed that they had produced pathological conditions analagous to those found in animals which had been infected with the virus of tuberculosis. Further experimentation soon showed that these were instances of *pseudo-tuberculosis*; that while the gross appearances of the lesions resembled true tuberculosis, inoculations with this material never reproduced the disease, while inoculations with tubercular material could be done through a series of animals without impairing the potency of the virus or varying the constancy of the results. Toussaint showed that true tubercle, both in man and animals, reproduces itself indefinitely with absolutely constant and identical properties, and that it is quite capable of being transmitted from animal to animal without losing its virulence.

Koch's discovery did not lead to such energetic search for the bacillus of tuberculosis among surgeons as physicians, because, as König asserts, the symptoms and signs of the tubercular affections coming under the notice of surgeons are

so characteristic that, for practical purposes, a correct diagnosis could be made in a majority of cases without a knowledge of their microbic nature and the improved methods for making a positive diagnosis derived therefrom. Koch called special attention to this fact, that the bacillus can be constantly found in the giant-cells and between the epithelioid cells in young tubercles, while it is more difficult to find it in cheesy products, unless caseation has taken place quite rapidly. Schuchardt and Krause ("Ueber das Vorkommen der Tuberkelbacillen bei fungösen und scrofulösen Entzündungen." *Fortschritte der Medicin*, B. i, S. 277) examined forty cases of tuberculosis of bones, joints, tendon-sheaths, and the skin, in Volkmann's clinic, and never failed in finding bacilli, although in some specimens careful and prolonged search had to be made. W. Mueller and Watson Cheyne have demonstrated experimentally that typical tuberculosis of bones and joints can be made artificially in animals by injecting tubercular material or a pure culture of tubercle bacilli directly into the tissues or indirectly by the way of the arterial circulation. It must now be considered as an established fact, based on clinical observation and experimental research, that all lesions, including affections of bones and joints, in which the microscopical and bacteriological characteristics can be found, must be regarded as tubercular in their origin and tendencies, thus establishing the microbic origin of tuberculosis upon a strictly scientific basis.

CHAPTER II.

Proofs which Establish the Tubercular Nature of the So-Called Strumous Disease of Bones and Joints.

For centuries most of the chronic inflammatory affections of bones and joints have, almost by common consent, been regarded as a local manifestation of a general dyscrasia, which, for want of a better knowledge, was called scrofula. Some of the text-books even at the present time continue to discuss the subject of strumous disease of bones and joints. Others, prominent among them, Sayre, of New York, and Bauer, of St. Louis, assign to trauma the principal rôle in the production of the inflammation, ignoring the action of a more subtle cause. I will now enumerate the most important evidences which tend to establish the fact that the diseases of bones and joints heretofore regarded as scrofulous or strumous in their origin, or the product of a chronic inflammation following an injury, are tubercular in their origin and their clinical tendencies, and the inflammatory product presents histological appearances which are identical with the tissue-lesions found in pulmonary and other well-recognized forms of tuberculosis in other organs.

Presence of Tubercle Bacilli in the Affected Tissues.—Tubercle bacilli are only found in the body in connection with tubercular affections, and their constant presence in the joint and bone affections now under consideration furnishes a strong proof of the tubercular nature of the lesions. Koch, Krause, Schuchardt, and Cheyne always succeeded in demonstrating the presence of tubercle bacilli in fungous disease of bones and joints.

Koch ("Die Ætiologie der Tuberculose." *Mitth. aus dem Kais. Gesundheitsamte*, B. xi, S. 1–188. Berlin, 1884) gives the result of his examination of thirteen specimens of bone and joint tuberculosis. He found tubercle bacilli within giant-cells and between epithelioid cells and the cheesy material in

all of them except one, and this was a case of tubercular abscess of the vertebræ in which no bacilli could be found in the pus, but inoculation experiments yielded positive results.

Castro-Soffia ("Recherches expérimentales sur la tuberculose des Os." *Thèse de Paris*, 1885) was one of the first to make a careful methodical search for the bacillus in tubercular lesions of bone. As the result of quite an extensive clinical investigation he assures us that he never failed in demonstrating the presence of the microbe, not only by microscopical examination, but also by inoculation experiments. In this connection it is well to mention incidentally that Schuchardt and Krause (*Fortschritte der Medicin*, May, 1883) have examined specimens from forty cases of surgical tuberculosis in the clinics at Halle and Breslau; they comprise:—

Synovial tuberculosis,	10 cases.
Osseous tuberculosis,	3 "
Glandular tuberculosis,	3 "
Cold abscesses,	14 "
Tubercle of muscle,	1 case.
Tubercle of tongue,	1 "
Tubercle of testicle,	1 "
Tubercle of female genitalia,	1 "
Miscellaneous,	6 cases.
Total,	40 "

In every one of these cases they found the characteristic bacilli.

Schlegtendal ("Ueber das Vorkommen der Tuberkelbacillen im Eiter." *Fortschritte der Medicin*, B. i, S. 537) examined five hundred and twenty specimens of pus from tubercular abscesses, and found bacilli present in about 75 per cent. of the cases. As the bacilli are never as numerous in tubercular pus as in the granulation tissue, there can be but little doubt that in the remaining 25 per cent. of the cases they were present, but were not discovered; or, perhaps, that in some of them the primary lesion was not of a tubercular nature. Experiments have repeatedly shown that pus from tubercular lesions in which no bacilli could be found produced, when injected into the

tissues of animals susceptible to inoculation, typical tuberculosis,—a positive demonstration that the material injected contained the essential cause of the disease.

W. Mueller ("Ueber den Befund von Tuberkelbacillin bei fungösen Knochen u. Gelenkaffectionen." *Centralblatt f. Chirurgie*, No. 3, 1884) has learned, from his own experience in the examination of numerous specimens of tuberculosis of bones and joints, that it is very difficult to find the tubercle bacilli in some of them. In about twenty specimens he failed to find them; nevertheless, he believes that they were tubercular, and that the bacilli were so few in number that their detection was difficult, or that they were not properly stained. In many of the specimens he found masses resembling drops of fat surrounded by fine granules, which could be deeply stained with methyl-violet, and expressed the opinion that these bodies were fragments or parts of bacilli, and were capable of reproducing the disease in animals by inoculation.

Mögling ("Die Chirurgischen Tuberculosen." Tübingen, 1884) found the bacilli never absent in tubercular pus from fifty-three patients.

Among others who have shown the never-failing presence of the bacillus in different forms of surgical tuberculosis, including bones and joints, may be mentioned Kanzler, Bouilly, and Letulle. Tuberculosis of bone and fungous disease of the joints, like lymphatic tuberculosis, have been, and by some are still, regarded as scrofulous affections. Kanzler wished to make a distinction between scrofula and tuberculosis, as he found bacilli not as constant in the former, and observed that, after implantation of tissue of what he regarded as scrofulous affections in animals, the process was slower than after inoculation with the products of recognized forms of tuberculosis. Letulle considers scrofula and tuberculosis as belonging to one and the same disease, of which the former constitutes the milder form and appearing externally, while the latter represents the graver form, attacking by preference the internal organs. The points

made by the last two authors are too unimportant for further consideration as a scientific or even practical distinction between scrofula and tuberculosis as applied to affections of the bones and joints. *The surgeon must recognize every lesion as tubercular in its origin, nature, and course in which the bacillus of tuberculosis can be found, from which successful cultivations can be made, and with which the disease can be artificially produced in animals by inoculation.*

Watson Cheyne asserts that as the result of his numerous experiments bacilli can always be found in the tissue-lesions, but that in most cases they were extremely few in number. He believes that the difficulty in finding them more constantly and in greater number is owing to our present defective means for staining them.

Direct Infection of a Joint through a Wound or Extension of Disease to it from a Tubercular Focus near a Joint.—A few well-authenticated cases are on record in which infection occurred by the entrance of the tubercular virus into a joint through a penetrating wound. Middledorpf ("Ein Fall von Infection einer penetrirenden Kniegelenkswunde durch tuberculöses Virus." *Fortschritte der Medicin*, 1886) reports the case of a healthy carpenter who opened his knee-joint by the cut of an axe and dressed the wound with a soiled handkerchief. The wound healed kindly, but later the joint became swollen, tender, and painful. Resection was performed, and on examining the capsule it was found very much thickened. In the granulation tissue bacilli were found. Czerny (*Centralblatt f. Chirurgie*, 1886) relates two cases in which tuberculosis followed in granulating surfaces treated by Reverdin's transplantation of skin. In both instances the patients were healthy, and the skin transplantation was made during the treatment of extensive burns. The skin was taken from limbs amputated for tubercular affections. In both cases tuberculosis of the adjacent joint occurred, and in one of them tuberculosis of the granulating surface. Verneuil refers to the case of a student who injured the fold of

the nail of his right ring-finger at a post-mortem, with the result of causing a local tuberculosis of the skin. This was treated in various ways without permanent improvement, and, after treatment of three years, there was still a tubercular ulcer on the finger and a tubercular abscess on the back of the hand. This abscess was opened and the ring-finger was amputated, but chronic abscesses continued to form, and the patient died, six years after the injury, of spinal meningitis, due to suppuration in connection with tubercular disease of the vertebræ.

In Pfeiffer's case, a veterinary surgeon, without any hereditary tendency to tuberculosis, punctured the phalangeal joint of his thumb while dissecting a tubercular cow. The wound soon healed, but the joint became the seat of a tubercular inflammation. Some months later symptoms of pulmonary phthisis set in, and he died a year and a half after the injury. The infected joint showed all the macroscopical and microscopical appearances of typical tubercular disease. Barker's ("Three Lectures on Tubercular Joint Disease and its Treatment by Operation." *British Medical Journal*, 1888, vol. i, pp. 1202, 1259, 1322) case was that of an assistant in the post-mortem room, aged 54, with good family history, who first inoculated his finger ten to fourteen years previously, and at that time the tubercular papilloma healed. Seven or eight years before his admission into the hospital he acquired another wart, which, however, disappeared under treatment, but had previously extended to the wrist, necessitating a resection of this joint. If a tubercular focus in bone or in the soft tissues near a joint perforates into a joint infection occurs at once, and the joint disease which ensues resembles the primary extra-articular lesion in every respect, showing conclusively that it resulted from the same essential cause.

Inoculation Experiments.—One of the most convincing evidences in support of the identity of fungous joint disease with well-recognized tubercular lesions in other organs is the fact that implantation of fragments of the diseased synovial

membrane into the subcutaneous tissue or peritoneal cavity of animals susceptible to tuberculosis almost without exception reproduces the disease in the animal.

Inoculation experiments have shown that it is necessary to inject a certain quantity of tubercular material or tubercle bacilli in animals in order to produce a positive result, which goes to prove that healthy tissues are capable of disposing of a non-pathogenic dose of the tubercular virus. Gerhardt experimented with the milk of tubercular cows, and found that, in cases where the original milk was virulent, it produced no effect, whether injected subcutaneously or into the peritoneal cavity, when it was diluted forty times or more. In experiments on feeding animals with phthisical sputum, he found that infection did not occur when the sputum was diluted more than eight times, although the same sputum diluted one hundred thousand times caused infection when injected subcutaneously. He has also ascertained that the disease runs a much slower course when the number of bacilli originally introduced was very small. Wyssokowitsch found that it was necessary to inject more than forty tubercle bacilli into the veins of rabits in order to produce infection, and he makes the same observations as to the more severe character of the disease the greater the number of bacilli primarily introduced. It has further been shown that the endothelium of the blood-vessels takes up microbes floating in the blood, and this fact is of great interest in connection with the development of tubercles from the vascular endothelium.

According to Pawlowsky ("Experimental Contribution to the Pathogenesis of Joints." *Annals of Surgery*, vol. x, p. 225) an intra-articular injection of a pure culture of tubercle bacilli in animals produces a well-marked incipient tubercular inflammation of the synovial membrane at the end of the fourth day. About the sixth day the membrane becomes rough and grayish, while there appears sometimes serous effusion into the joint, and swelling of the adjacent lymphatic glands. On the twelfth day he found joints thus artificially injected dis-

tended with fluid, and the para-articular tissues swollen and œdematous. By the end of three weeks the process advanced to the formation of granulation tissue and beginning suppuration. Microscopical examination of the synovial membrane shows that the bacilli invade the tissues along the course of lymphatic vessels and connective-tissue spaces. General infection is prevented indefinitely by a zone of lymphatic glands.

Tavel (Senn: "Four Months Among the Surgeons of Europe," p. 154. Chicago, 1887) has for several years resorted to implantation experiments as a means of diagnosis in obscure cases, and the results obtained have yielded infallible diagnostic information. Granulation tissue from tubercular joints in his experiments on guinea-pigs invariably produced acute, diffuse tuberculosis, and death in from five to six weeks. The course of the disease in the animal is typical; at the point of inoculation a hard nodule appears first, the result of a traumatic inflammation of the tissues around the graft. Next, a lymphatic gland becomes enlarged in the immediate vicinity of the primary seat of infection, which was invariably the inguinal region; consequently, the inguinal glands enlarged first. Glandular infection increases rapidly; after the whole chain of lymphatic glands in the groin are involved, the axillary glands become affected. Death occurs in the course of five or six weeks. At the post-mortem it was always found that of the internal organs the spleen becomes affected first, then the liver and lungs, but usually the disease is so diffuse that scarcely an organ remains entirely exempt. When the diagnosis between a syphilitic and tubercular disease of a bone or joint cannot be made either clinically or by aid of the microscope, inoculation experiments always give positive and reliable information. When the lesion is tubercular the disease is always communicated to the animal through the graft, and the animal dies of miliary tuberculosis within six weeks. When it is syphilitic, the inoculation is harmless and the animal remains well. At the time Tavel communicated these facts to me, only one guinea-pig that was

inoculated with tubercular material had survived the infection and was living at the end of five months, and in this case a large abscess formed at the point of inoculation a few weeks later. Examination of the contents of the abscesses showed a large number of bacilli; a gland in the groin remained enlarged, and the disease, if not arrested by the suppurative inflammation, had probably passed into a latent stage.

In Kocher's wards at Berne (*British Medical Journal*, June 29, 1888), the inoculation of guinea-pigs has been employed for some time as a bacteriological test of the existence of tubercular disease, such animals being very susceptible, and the development of the affection in them being rapid enough to permit of a positive diagnosis being made in from two to four weeks. From the results obtained in one hundred and twenty cases where this diagnostic inoculation was practiced, from one to five animals being used in each case, Tavel lays down the following propositions: 1. If the case is of a tubercular nature, inoculation invariably gives rise to the development of tuberculosis in the animal experimented upon. 2. The method requires far less time and trouble, and gives more trustworthy results than microscopic examination. 3. The method is certain, even where anatomical examination is practically impossible.

Cheyne has been equally successful in transferring the disease from man to animal by implantation of granulation tissue from tubercular bones and joints. Inoculation experiments are equally valuable in making a differential diagnosis between true and tubercular abscess. If a hypodermatic syringe is filled with the contents of an abscess from a case in which it is necessary to make a correct diagnosis, and the injection is made into the peritoneal cavity of a guinea-pig, the result following will make a positive diagnosis. If it is true pus, the injection will either be harmless, if the peritoneal cavity possesses sufficient absorptive capacity to absorb the pus and eliminate the pus-microbes, or a circumscribed or diffuse suppurative peritonitis will follow promptly. If, on the other hand, the abscess is tubercular the

injection will produce a typical tubercular peritonitis and death from miliary tuberculosis.

Artificial Production of Bone and Joint Tuberculosis in Animals by Direct Inoculation.—It has already been shown that tubercular joint disease in man has been caused by direct inoculation of the joint through a penetrating wound or extension of the disease to it from an extra-articular focus near to it. The same results have been produced in animals artificially by direct inoculation. Hueter ("Ueber scrophulöse u. tuberculöse Gelenkentzündung." *Verh. der Deutschen Gesellschaft f. Chirurgie*, B. vii, S. 107) was positive in his assertions that scrofulous and tubercular affections of joints were identical anatomically and etiologically. He succeeded regularly in producing tuberculosis of the iris by implanting into the anterior chamber of the eye in rabbits fragments of granulation tissue taken from a fungous synovial membrane. Schueller ("Untersuchungen über die Entstehung und Ursache der scrofulösen und tuberculösen Gelenkleiden," 1880) claimed in 1880 to have discovered the microbe of tuberculosis by fractional cultivation from lupus-tissue, which when conveyed into the vessels of the lungs produced phthisis, and when injected into joints tubercular inflammation, caseation, and finally miliary tuberculosis.

The same author ("Experimentelle und Histologische Untersuchungen über Entstehung der Skrofulösen u. Tuberculösen Gelenkleiden." Stuttgart, 1880) studied the localization of the tubercular virus experimentally in the same manner as others have studied the localization of pus-microbes. He inoculated animals with the products of tubercular inflammation, subsequently produced contusions and sprains of joints, and observed that localization usually occurred at the seat of injury. If the tubercular virus was introduced by inhalation, the same typical lesions occurred in the injured joints as when injection was made more directly. In all cases the products of the local lesion corresponded with the character of the material introduced through some remote point.

W. Mueller ("Experimentelle Erzeugung der typischen Knochentuberculose." *Centralblatt f. Chirurgie*, 1886, p. 233) produced experimentally the typical form of tuberculosis in bone by the injection of tubercular material into the nutrient artery of the tibia. König has claimed for a long time that the wedge-shaped sequestrum so frequently found in tubercular foci in the articular extremities of the long bones was due to occlusion of a small artery by a tubercular embolus. Mueller proved the correctness of this conclusion derived from clinical observation by experimentation. He made sixteen experiments on rabbits, injecting tubercular pus into the femoral artery, some in a peripheral, some in a central, direction, without any positive results. In a second series the same material was thrown into the nutrient arteries of the femur and tibia. Of ten of these cases, two showed a tubercular focus in the medulla of the diaphysis of the tibia; in another case miliary tuberculosis in the femur and tibia, and in the latter bone a small caseous spot in the spongy part, which contained numerous bacilli. The animals were killed eight weeks after the injection, and showed no evidences of organic disease, except a few tubercles in the lungs. Twenty experiments were made on young goats, five on sheep, and two on dogs. The tubercular material was injected directly into the nutrient artery of the tibia, the tibial artery being tied above and below the vessel. Primary union of the wound was obtained in all cases except in one dog. In the dogs and sheep, all experiments yielded negative results. In the goats, bone affections were produced which were identical with tubercular bone-lesions found in man. Most frequently the disease was established in the diaphysis, cheesy masses and granulation tissue showing themselves in the medulla, the result of tubercular osteomyelitis with or without sequestration. Typical lesions were also found in the ends of the bones, with and without implication of the adjacent joints. In two of these cases the epiphysis was affected, while in three the shaft alone was involved. The following experiment furnishes a good illus-

tration of the identity of the bone disease produced experimentally and the disease as it occurs in man. Tubercular material was injected into the tibial artery of a goat three months old. Wound healed in eight days. Some lameness four months later, gradually increasing during the next nine months. At the same time a swelling appeared at the knee-joint. Tibia painful on outer side. Animal killed thirteen months after the injection. There was found a typical fungous disease in the knee-joint most advanced at the sides, a wedge-shaped sequestrum in one of the tuberosities of the tibia, and a small granulation mass in the centre of the head of the tibia, and two similar granulating foci in the lower epiphysis of the femur. With the exception of the lymphatic glands of the knee-joint, no other organs were affected. In some cases pulmonary tuberculosis developed, twice general miliary tuberculosis. The rest of the animals were killed when they began to show lameness, —fourteen days to thirteen months after the inoculation. The tubercular lesions thus produced were examined for bacilli, and these were constantly found. The starting-point in every instance must have been a tubercular embolus in one of the small arterial branches in the extremity of the affected bone. Phthisical sputum or a pure culture of tubercle bacilli injected directly into a bone or joint will produce a localized tuberculosis in rabbits, goats, and other animals susceptible to infection.

Cheyne (*British Medical Journal*, April 11, 1891) injected tubercular sputum, diluted with distilled water, into the knee-joints of two rabbits, and produced in this way a typical synovial tuberculosis, with extension of the disease later to the cartilages and articular extremities. In two rabbits, holes were drilled in the upper part of the tibia and tubercular sputum injected into the interior of the bone. In the first experiment the result was very slight; the second animal showed, in a short time, evidences of a positive result, and was killed ninety-one days after inoculation. The specimen revealed a focus of tuberculosis in the interior of the bone, at the point of inoculation, which had

extended to the epiphysis and finally to the synovial membrane, at a point corresponding to the posterior recess of the capsule of the joint. The results obtained in four guinea-pigs were not as typical as in the rabbit. Injection of an emulsion of tubercular pus in distilled water into the femoral artery of a rabbit produced a cheesy mass in the upper part of the tibia, just below the epiphysial line. There was no tuberculosis in any of the internal organs. Injection of an emulsion of a pure culture of tubercle bacilli—made by taking the culture from a tenth series of tubes from Koch's laboratory and rubbing it up in distilled water—into the knee-joints of a number of rabbits produced in every instance typical tuberculosis, followed by extension of the disease to the cartilages and articular extremities of the bones. In three cases a similar injection was made into the lower epiphysis of the femur, and in each instance with positive results. The experiments made on goats, by injecting the tubercular material directly into joints, nutrient artery of tibia, and epiphysial extremities of the long bones, yielded positive results.

Krause ("Die Tuberkulose der Knochen und Gelenke." Leipzig, 1891) produced tuberculosis of joints in rabbits by injecting pure cultures suspended in distilled water. Two weeks after the injection he found the joint swollen, and the animal dragged the leg in walking. The swelling increased quite rapidly, and the temperature of the surface of the joint was increased. As a rule, the animal died in from four to five weeks. In every specimen examined the para-articular tissues were much swollen, and in one of the animals an abscess had formed outside of the joint. The synovial membrane was always found swollen and very vascular, but its inner surface was usually smooth. In the superficial layers miliary nodules are few; but these were more numerous near the surface. Some of the nodules were larger and showed central caseation. The histological structure of the nodules was typical. In guinea-pigs he infected the animals by injecting a pure culture into the subcutaneous connective tissue in one of the inguinal regions.

Ten days after the injection a nodule formed at the point of puncture, followed by infection of the inguinal glands. About the eleventh day he produced injuries of joints and bones, such as sprains, contusions, and fractures. In rabbits the injuries were preceded by intra-peritoneal or intra-venous injections of pure cultures. The latter method of injection was often followed by death from acute miliary tuberculosis before the process had time to locate at the seat of injury. The animals that survived the injection three to seven weeks furnished positive results in reference to disease of the injured joints and bones. Of fifteen guinea-pigs that were inoculated, and in which injuries of bones and joints were produced, and that died of general tuberculosis, only in one were the bones and joints intact. The fractures united by bony callus; the process of repair showed no deviation from that in healthy animals. There were no evidences of tubercular disease. Of three dislocations of large joints, only in one was the capsule the seat of tubercular disease. Of forty-four sprained joints, only fifteen became tubercular. In these cases the synovial membrane was infiltrated with round-cells and quite vascular. The nodules, which often attained considerable size, were made up of round and epithelioid cells. In the centre of the larger nodules was incipient caseation; no giant-cells; tubercle bacilli always present, but few in number; articular cartilages normal. In six cases there was well-marked tuberculosis in the medulla of the epiphysial extremities of the long bones. Bacilli in this locality were as scanty as in the synovial membrane.

In one specimen in the lower end of the femur he found three emboli which contained tubercle bacilli. In the rabbits that were inoculated he produced twenty-eight sprains in as many different joints, and found later tubercular lesions in half of the injured joints. The fractures made in these animals healed in the same manner as in the guinea-pigs, by bony union without a sign of tuberculosis, although tubercles in the medullary tissue were found more frequently than in the guinea-pigs; but these, when present, were always found from one to several

centimetres distant from the fracture. In the joints thus infected the disease was limited to the synovial membrane. Caseation appeared sooner than in the guinea-pigs. Of seventy-nine distortions of joints in rabbits and guinea-pigs, only in twenty-nine did the injured joint become the seat of disease, although all of the animals died of general tuberculosis. Only in a single case, in a rabbit, did a healthy joint become the seat of tubercular infection; in all the other cases the injury determined the localization.

Association of Bone and Joint Tuberculosis with Tuberculosis in Other Organs.—The frequency with which joint and bone tuberculosis gives rise to tuberculosis in other organs points to a direct etiological relationship between the primary and secondary affection. Every surgeon is also conversant with the familiar clinical fact that bone and joint affections frequently develop in the course of tubercular affections in other organs, showing again a causative connection between the primary and secondary disease. Cheyne (*British Medical Journal*, April 11, 1891, p. 790) states that, of 386 patients suffering from bone or joint tuberculosis observed for a period of three years, after the termination of treatment, forty-two, or 10 per cent., had become affected with or had died of phthisis or some other form of tuberculosis. Billroth and Menzel found, on searching the post-mortem records at Vienna for a period of 50 years (1817–1867), that there had been 2106 cases of caries of bones and joints, and of these more than half were complicated with tuberculosis of the internal organs. Neumeister has collected 438 cases from the Würzburg clinic and other sources, with sixty, or 15 per cent., of deaths from acute tuberculosis. Willemer has ascertained, from statistics which he collected and studied, that in the case of chronic affections of the knee-joint, 1 per cent. of the patients die of tuberculosis during the first year of the disease, 7 per cent. during the second, 6 per cent. during the third, making a mortality of 14 per cent. from acute tuberculosis within three years. König states that in only 21 per cent. of all cases of joint tuberculosis is the disease confined to the joint.

Microscopical Structure of Diseased Tissue and Caseation of Inflammatory Product.—Rokitansky, Virchow, Köster, Kiener, and others have shown that the primary nodules in bone and synovial membrane during the early stages of tubercular disease show, under the microscope, the same structure as miliary tubercle in the lungs. The primary inflammatory product is a minute tubercle, in which the same histological elements can be found and can be seen to be arranged in a similar manner as in miliary tubercles in the lung. The primary tubercle here, like in the lung, is an avascular structure, and undergoes the same secondary pathological changes as in the latter organ. *Coagulation necrosis and caseation of the inflammatory product takes place, slower, but with the same regularity in tubercular products in bone and joints as in pulmonary phthisis. The very fact that the inflammatory product in bone and joint tuberculosis presents the same histological structure, and is subject to the same pathological changes as tubercle in the lungs, warrants the assertion that they are produced by the same cause and undergo analogous degenerative processes.*

Reaction to Tuberculin.—One of the benefits derived from the treatment of tubercular affections with Koch's lymph is the knowledge gained, that tubercular affections of bone and joints react under the use of tuberculin in the same manner and with the same promptness as tubercular lesions in the lungs. The general reaction is often very intense, as I have observed a temperature of nearly 106° F. six hours after injection of 5 milligrammes of tuberculin in a case of uncomplicated synovial tuberculosis in a girl 18 years of age, who had a normal temperature before the injection was made. The local reaction is prompt, and sets in within twelve hours after the administration of the remedy, and consists of swelling, increased pain, and tenderness,—in fact, the substitution of a brief acute attack in place of the chronic inflammation.

CHAPTER III.

Bacillus Tuberculosis.

The bacillus tuberculosis, bacillus Kochii or tubercle bacillus, is one of the smallest of the known bacilli. In length it is about one-fourth to three-fourths of the diameter of a red blood-corpuscle. It appears in the tissues and cultures in the shape of very thin rods from two to eight micromillimetres in length, and rounded at the ends. (Plate I, Fig. 1.)

The length is always from five to six times greater than its breadth. In cultures the bacillus is always somewhat shorter and more delicate than in the living tissues. The largest bacilli can be found in phthisical sputa. In the tissues and in fresh cultures the bacilli appear as nearly straight rods, while in old cultures and in the expectoration of phthisical patients they are often curved, and sometimes acutely flexed. As a rule, they are seen under the microscope as isolated rods; only seldom are they arranged in pairs, and when this is the case the two rods form an obtuse angle. The tubercle bacillus is a non-motile microbe, and consequently possesses no power of locomotion, and it cannot penetrate on the tissues without assistance. In old tubercular products and cultures the rods do not stain uniformly; oval spots in their interior do not take up the staining material and impart to the rods a chain-like appearance.

Koch has interpreted these light spots as endogenous spores. Sporulation occurs within the living body when the bacillus is imbedded in a soil favorable to its rapid growth and reproduction. The staining properties of the tubercle bacillus are of a specific and peculiar nature, which distinguish this microbe from all other pathogenic organisms. Koch's original assertion that the bacillus can only be stained with alkaline aniline dyes, or by the addition of aniline oil, carbonic acid, etc., has not been sustained by subsequent researches, as this microbe can be stained with an aqueous or alcoholic solution of aniline dyes,

PLATE I.

FIG. 1.—TUBERCLE BACILLI CONTAINING SPORES. Zeiss $\frac{1}{18}$ 0.4. (R. Koch.)

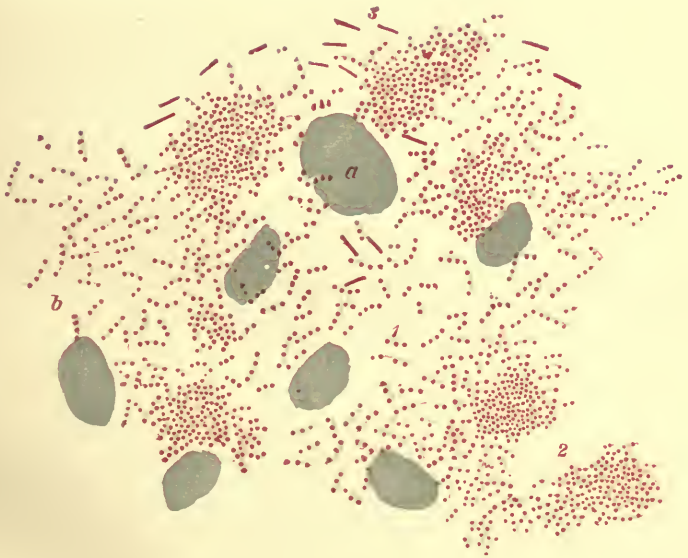

FIG. 2.—TUBERCLE BACILLI FROM A TUBERCULAR CAVITY. CARBOL-FUCHSIN, NITRIC ACID, METHYL-BLUE. Zeiss $\frac{1}{18}$ 0.4.

although not as intensive or brilliantly as with the more complicated solutions. In reference to the staining process, tubercle bacilli differ from all other known pathogenic microbes, in that they are penetrated very slowly by the aniline dyes, and in their specific behavior to decolorizing agents like mineral acids and alcohol. Upon what this differential behavior rests is as yet unknown. For section-staining Ehrlich's method is the best:—

Saturated alcoholic solution of methyl violet or fuchsin,	11 parts.
Aniline water,	100 "
Absolute alcohol,	10 "

Sections are left for twelve hours in this solution. Treat the specimen with 1:3 solution of nitric acid a few seconds. Wash in alcohol (60 per cent.) for a few minutes; after stain with diluted solution of vesuvin or methylene blue for a few minutes; wash again in 60-per-cent. alcohol, dehydrate in absolute alcohol, clear with cedar-oil, mount in Canada balsam. Ziehl-Neelsen's method has also been frequently employed; 100 grammes of distilled water are mixed with 5 grammes of crystallized carbolic acid and 1 gramme of fuchsin, and to the filtered solution 10 grammes of alcohol are added. As a decolorizing agent a 5-per-cent. solution of sulphuric acid is used. The remaining technique is the same as in Ehrlich's method. (Plate I, Fig. 2.)

The examination of fluids for tubercle bacilli can be done rapidly and very satisfactorily by Gibbes' method.

Gibbes' Magenta Solution.

Magenta,	2 parts.
Aniline oil,	3 "
Alcohol (specific gravity 0.830),	20 "
Distilled water,	20 "

Stain cover-glass preparation in this solution for fifteen or twenty minutes; wash in (1:3) solution of nitric acid until the color is removed; rinse in distilled water. After stain with methylene blue, methyl green, iodine green, or a watery solution of crysoidin, five minutes; wash in distilled water until no more

color comes away. Transfer to absolute alcohol for five minutes, dry, and preserve in Canada balsam. Fränkel's method requires only four minutes. Aniline water with 7 per cent. of alcohol is boiled in a test-tube and is then poured in a watch-glass and saturated with an alcoholic solution of fuchsin. This staining material is always prepared fresh, and from it the slide preparation is dipped into a mixture of acid with methyl blue (50 parts distilled water, 30 parts alcohol, 20 parts nitric acid, methyl blue as much as can be dissolved). After this, as in Ehrlich's method, wash in water or a weak acid solution, 1 per cent. acetic acid, 50 per cent. alcohol; examination of specimen in water, or, after drying in alcohol-flame, mount in Canada balsam.

The best culture medium of the tubercle bacillus is solid sterilized blood-serum of the cow or sheep, with or without the addition of gelatin, at a temperature of 37° to 38° C. (98.6° to 100.4° F.). The bacillus grows very slowly and only between the temperatures of 30° and 41° C. (86° and 105.8° F.). In about a week or ten days the culture appears as little whitish or yellowish scales and grains. In cultures on serum ten to fifteen days elapse before growth can be detected by the unaided eye. (Plate II, Fig. 3.)

The bacillus can also be cultivated in a glass capsule on blood-serum, and the appearance of the growth studied under the microscope. The scales or pellicles are then seen to be made up of colonies of a perfectly characteristic appearance. (Plate III, Fig. 4.)

The growth ceases after three or four weeks. The blood-serum is not liquefied, unless putrefactive bacteria contaminate the culture. Besides solidified blood-serum, the only substance on which the tubercle bacillus can be cultivated is agar (meat-infusion peptone-agar), and in fluid blood-serum and bouillon. According to Nocard and Roux, the addition of glycerin to the proper nutrient media favors the growth of the bacillus. The bacillus of tuberculosis offers a somewhat high degree of resist-

PLATE II.

Fig. 3.—Vegetations of Tubercle Bacilli upon Sterilized Blood-Serum, Twenty-Six Weeks Old. Natural Size. (Baumgarten.)

PLATE III.

FIG. 4. — TUBERCLE BACILLI. COLONY ON SOLIDIFIED BLOOD-SERUM, FOURTEEN DAYS OLD; STAINED WITH CARBOL-FUCHSIN, DECOLORIZED WITH DILUTE NITRIC ACID. × 100. (Fränkel and Pfeiffer.)

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PLATE IV.

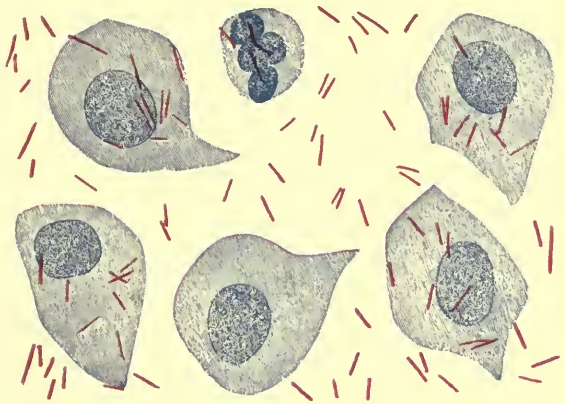

Fig. 5.—Glass-Slide Preparation from the Tissue-Juice of a Fresh Inoculation Tubercle. Ehrlich's Staining. Zeiss, homog. immers., $\frac{1}{12}$ 0.4, magnified about 1500 times. (Baumgarten.)

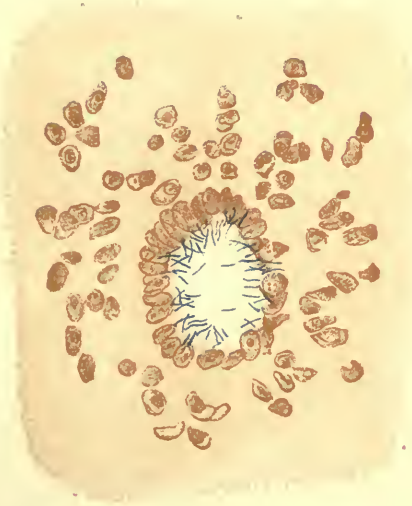

Fig. 6.—From Encysted Bronchial Glands in Miliary Tuberculosis. Giant-Cell with Radiating Arrangement of Bacilli. 700 diam. (Koch.)

ance to injurious influences from without, and is thus able to preserve its power of infection under circumstances which would prove fatal to most other pathogenic microbes. It can bear temperatures approaching the boiling-point, though it is soon destroyed if it is heated in a thoroughly moist condition. Schill and Fischer have fixed the thermal death-point of the bacillus of tuberculosis at 212° F., with an exposure to this temperature of four minutes. It was not affected by drying during a period of 186 days, or by being kept in putrefying sputum for 43 days. No attempt has been made to determine precisely how far these powers of endurance are confined to the spores or belong also to the vegetative rods, but our knowledge of the life-history of other microbes would indicate that the spores possess a greater power of resistance to thermal and chemical agents than the protoplasm of the bacillus. The bacilli and spores succumb more readily to chemical agents than heat. Cavagnis, Schill, and Fischer found that they were destroyed in a 3-per-cent. solution of carbolic acid in 20 hours. Cavagnis ascertained that the bacilli in tubercular sputum are destroyed in a 1 to 5000 solution of corrosive sublimate in 20 hours, and in a stronger solution in a much shorter time.

Experiments and clinical observation have shown that iodoform, if it does not possess the power to destroy the bacilli and their spores, at least exerts a potent inhibitory effect on the growth in the tissues, to which must be attributed at least one of its therapeutic actions in the treatment of tubercular affections. In the tubercular tissue the bacilli are found within and between the epithelioid and giant cells. (Plate IV, Fig. 5.)

In the giant-cells the bacilli occupy the periphery of the cell where they are arranged in a radiate manner, singly or in pairs. (Plate IV, Fig. 6.)

The number of bacilli diminishes toward the centre of the cell where coagulation necrosis has occurred. The bacillus disappears in old tubercular products, caseous material, and tubercular pus; but these substances retain their infectious proper-

ties, owing to the presence of living spores, which remain indefinitely in an active condition in soils in which the bacillus cannot thrive and grow. It is on this account that in active tubercular foci with a central area of degeneration the bacilli are found in greatest number toward the periphery of the inflammatory product within and between the living cells.

CHAPTER IV.

Histology of Tubercle.

A correct knowledge of the minute morbid anatomy of tubercular disease of bones and joints is of great practical importance at the present time, as the tendency among surgeons now is to limit operative procedures to removal of diseased tissue only. The microbic cause of the tubercular inflammation resides within, between, and in the immediate vicinity of the cells which constitute the inflammatory product, and in order to treat successfully a tubercular lesion in a bone or joint by direct surgical procedures it is necessary to remove all of the histological elements of the inflammatory lesion and the product of cell degeneration, or to destroy the tubercle bacilli by antibacillary agents. A primary tubercle is an aggregation of cells, the product of a minute focus of inflammation, produced by the presence of the essential cause of tuberculosis. The primary nodule is invisible to the naked eye, and when it becomes so large that it can be recognized without the aid of the microscope it already consists of a confluence of a number of minute microscopic nodules. For a long time great confusion prevailed in regard to the identity or non-identity of caseous foci and gray or miliary tubercle. Some pathologists believed these formations represented the product of distinct and specific types of inflammation, while others regarded them as different stages of the same process. The distinguished Laennec entertained the latter view. This author described four varieties of tubercle: 1. Miliary tubercle, where the visible product of tubercular inflammation appears in the form of nodules the size of a millet-seed, of a grayish color, and usually arranged in groups. 2. Crude tubercle, where the miliary nodules have become confluent and undergo cheesy degeneration. 3. Granular tubercle, where the nodules are extremely small, nearly the size of a millet-seed, and scattered uniformly through a whole organ. They are not arranged in groups, and

have no tendency to become confluent. In the centre they become transformed into yellow tubercle. 4. Encysted tubercles, or such as are constituted of a hard mass of crude tubercle in the centre, surrounded by a firm, fibrous capsule. These varieties only represent different phases of the same process and different stages of inflammation produced by the same cause.

The anatomico-pathological basis of tubercle was created by Virchow, and has been firmly established through the laborious researches of Langhans, Wagner, Klebs, Schueppel, Rindfleisch, Köster, Friedländer, Fox, Baumgarten, and many others. The specific-cell theory has had many able advocates and has been the subject of many animated discussions; but it has at last been abandoned as fallacious and unscientific. Lebert's tubercle-corpuscle is a thing of the past, and is only referred to as a landmark in the history of tuberculosis. There are no specific tubercle-cells. Reinhart showed that these cells, which were regarded by Lebert as characteristic and pathognomonic of tubercle, could be found in all products of chronic inflammation, and their presence was only an evidence that a certain amount of inflammation existed. When we speak of a tubercle we mean a nodule or granule, which is composed of leucocytes derived from the capillary vessels damaged by the bacillus of tuberculosis, or new cells resulting from tissue-proliferation of pre-existing cells acted upon by the same cause. The distinguishing anatomical character of the nodule consists not in the presence of any particular cell-elements, but in the peculiar arrangement of the cell; and this feature is the only reliable anatomical guide in making a diagnosis by the use of the microscope. The product of tubercular inflammation occurs either in the form of submiliary, microscopic granules, visible miliary nodules, or a cheesy deposit, which may occupy an entire organ, as a lymphatic gland; or large, isolated foci, as in bone. Every tubercular product commences as submiliary nodules, which, when they become confluent, are transformed into visible, gray, miliary nodules, which again coalesce after they have under-

gone caseous degeneration from cheesy masses, which may be either small and circumscribed or large and diffuse.

Virchow defines a tubercle as a nodule representing a heterogeneous growth,—a product originally necessarily of a cellular nature,—taking its starting-point from the connective tissue or from other mesoblastic structures, as marrow, fat, lymphoid tissue, or bone. He asserts that the microscopic or submiliary granule contains all the essential histological elements of tubercle, and, by aggregation, forms the ordinary miliary nodule of Laennec. When the nodules become confluent they may form masses the size of a walnut, surrounded by a common zone of embryonal tissue. The yellow tubercle—the crude tubercle of Laennec—is a more advanced stage of the gray, the histological elements of the latter having undergone caseation. Tubercular tissue in bone and joints, as in other organs, presents itself in two forms,—either as a circumscribed nodular product or tubercular infiltration,—and both forms are often seen in the same specimen. In the diffuse variety the epithelioid cells are not collected in small masses, but they are scattered irregularly through the other tissues. The part which is the seat of this infiltration presents two types, namely, granulation tissue or young fibrous tissue. In the former the granulation tissue contains numerous epithelioid and giant cells. This condition is found in synovial membranes, where caseation is in progress, and also precedes the formation of abscesses, and the disease always manifests progressive tendencies. The fibrous form is best seen in caries, and we find young fibrous tissue infiltrated with epithelioid and giant cells, and is characterized by a lesser tendency to degeneration.

Minute Anatomy of Tubercle.—The essential histological elements which make up a primary tubercle-nodule are: (*a*) leucocytes; (*b*) giant-cells; (*c*) epithelioid cells; (*d*) reticulum.

Leucocytes.—One of the convincing proofs of the inflammatory nature of tuberculosis is the presence of leucocytes in the tubercular nodule. The bacillus of tuberculosis appears to

exercise only a mild pathogenic effect on the capillary wall, and the primary inflammatory product is always scanty. As the colorless corpuscle can only escape in considerable number through inflamed capillary walls which have undergone alteration from the action of some specific microbic cause, it is evident that its migration into the paravascular tissues, where it forms a part of the tubercular product, can only occur after such alteration has taken place from the action of the bacillus upon the cement-substance of the endothelial lining of the

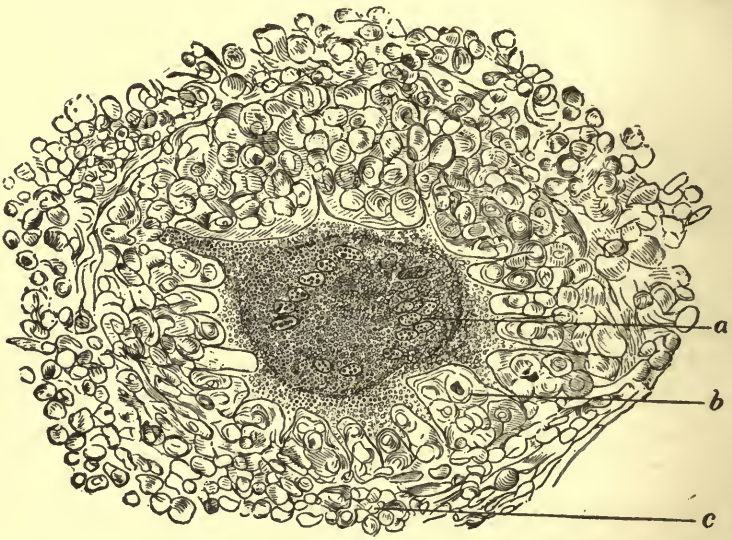

FIG. 7.—PRIMARY TUBERCLE. × 350.
a, giant-cells; *b*, epithelioid cells; *c*, leucocytes.

capillary vessels. *The leucocytes invariably undergo degenerative changes, and are never transformed into other forms of cells found in the tubercular product.*

Although constantly present, they are most numerous when the process is acute. The leucocytes are most numerous in the peripheral zone of the tubercle-nodule, but they are also found between the epithelioid and giant cells, gaining entrance into the interior of the nodule by migration.

Giant-Cells.—After Virchow had repeatedly called atten-

tion to the occurrence of giant-cells in tubercle, Langhans ("Ueber Riesenzellen." Virchow's *Archiv*, B. xlii, S. 382) made the histogenesis and structure of these cells the subject of special study. He found them almost constantly in recent tubercle. He showed that while their morphological characters vary greatly they resemble each other, in that they always contain numerous nuclei which are arranged radiate toward the centre of the cells in their periphery, and, further, that many of them are surrounded by a granular, striped, often

FIG. 8.—GIANT-CELL FROM CENTRE OF TUBERCLE OF LUNG. × 450.
(*Hamilton.*)

A, granular protoplasmic centre; B, peripheral more-formed part; C, crescent of nuclei; D D, endothelial cells; E E, two vacuoles within the giant-cell, or are arranged in a crescent at one end.

very thick envelope. Besides these large cells with homogeneous envelopes, he described many intermediate forms between these and cells with a complete capsule. He believes that giant-cells are genetically different things, as they originate from small multinuclear cells, others from stellate cellular elements; while those with cell-mantels are produced by confluence of cells which retain their nuclei. The giant-cells, or, as Klebs calls them, *macrocytes*, are finely granular, and contain multiple nuclei, which usually occupy the periphery of the cell.

The giant-cells are the most striking histological elements in a tubercle, but as they are not constantly found they are not essential. The giant-cell found in tubercular tissue has its prototype in normal tissue. The giant-cells were first discovered in normal tissue (marrow of bone) by Robin, who called them *myeloplaques*. Wegner ("Myeloplaxen und Knochenresorptionszellen." Virchow's *Archiv*, B. lvi, S. 523), as the result of his own careful investigations concerning resorption of bone in normal and pathological conditions, maintains that the giant-cells—or *osteoclasts*—which perform this function are not produced by the bone-cells. He has traced them to small cells of the blood-vessels, which, at first, contain only one nucleus, but later increase in size, and at the same time become multinuclear. He has found such cells always in the immediate vicinity of capillary vessels and small arteries and veins. In a normal condition they are constantly found in bone and the placenta. They are also found occasionally in fat-tissue, especially in cases of rapid emaciation. Kundrat has found them in inflamed serous membranes, and Stricker and Heitzmann in the inflamed cornea. They are always found around foreign bodies, becoming encysted in the tissues. Friedländer found them present in the alveoli of the lungs in cases of chronic pneumonia.

FIG. 9.—A GIANT-CELL FROM THE LUNG IN A CASE OF CHRONIC PHTHISIS, SHOWING THE LARGE NUMBER OF NUCLEI WITH EIGHT NUCLEOLI. ×400. (*Green.*)

Heubner found giant-cells in endarteritis, Baumgarten in gummata, Buhl and Jacobson in granulating wounds, and finally Johne and Pflug in actinomycotic foci. *The giant-cells found in inflammatory products under such variable circumstances resemble the large multinuclear cells found in some forms of sarcoma, and appear to be simply certain embryonal cells*

which have outgrown others by taking up a greater amount of nourishment in the shape of leucocytes which have undergone fragmentation. Watson Cheyne believes that they are derived from epithelioid cells, either by hypernutrition or coalescence of neighboring cells. The histological source of these cells has been traced to epithelial cells by Zielonko and Weigert; to endothelial cells by Kundrat, Klebs, Herrenkohl, and Zielonko; to connective tissue or endothelial cells by Virchow, Fleming, and Ziegler. Schueppel and Rindfleisch believe that they invariably originate within blood-vessels or lymphatics, where these authors regard them as the first step toward the development of tubercle-nodules. Ziegler claims to have seen giant-cells develop from white blood-corpuscles. Herig, Aufrecht, Woodward, Schueller, and Treves are of the opinion that what appear as giant-cells in tubercular tissue are not cells, but only represent spaces which correspond to transverse sections of lymphatic vessels, the portion of the cell representing the protoplasm being the coagulated lymph within these vessels, and what appear as nuclei being enlarged, swollen, endothelial cells. Each tubercle usually contains one giant-cell in its centre. The periphery of the giant-cell presents projections or protoplasmic strings uniting with the epithelioid cells, or ramify among these cells. Young giant-cells possess amœboid movements, and by virtue of these they are capable of taking up in their protoplasm fine particles—such as microbes, pigment material, and blood-corpuscles—which have undergone fragmentation.

Ruffer ("Notes on the Destruction of Micro-organisms by Amœboid Cells." *British Medical Journal*, August 30, 1890) has lately discovered, quite accidentally, one fact which illustrates the destructive function of giant-cells. In the spleen of many animals, more especially of guinea-pigs, the non-nucleated epithelioid cells often contain a quantity of pigment, which is really the remainder of red corpuscles, destroyed in the interior of these cells. Ruffer has shown that the number of these cells is greatly increased in certain infective diseases,—that is,

quarter-evil. In the spleen of tubercular guinea-pigs, in which the tubercle has invaded that organ, the destruction of red blood-corpuscles in the macrophages of the spleen is an extremely active one; but—and this is the most interesting point—the giant-cells of tubercle take an active part in this process, and the same author has demonstrated in their interior blood-pigment and *débris* of partially digested leucocytes,—a further proof that giant-cells are amœboid, and, like other amœboid structures, have the power of taking into their interior and digesting red blood-corpuscles, leucocytes, and micro-organisms. *The giant-cells in tubercular tissue are nothing more nor less than hyperplastic epithelioid cells, and, consequently, are derived from the same histological source as these.*

Epithelioid Cells.—Cells intermediate in size between the giant-cells and the leucocytes are found in every tubercle-nodule in which cell identity has not been destroyed by caseation and liquefaction of the tubercular product. These cells were first described by Rindfleisch, and were called by him *epithelioid cells*, from their structural resemblance to epithelial cells. Klebs calls them *platycytes*. They are about two or three times larger than a white blood-corpuscle, and in shape they are round, or somewhat elongated. (Fig. 5.) In structure they are finely granular, and contain one large nucleus and often a number of small nuclei. They form the bulk of all recent nodules, are scattered between the giant-cells, and are often arranged in layers around them. Baumgarten has found that in tubercular tissue karyokinesis only occurs in the epithelioid cells and in the cells from which they are derived, and hence he comes to the conclusion that they are the essential histological element of tubercle. The histological source of these cells was supposed to be the leucocyte by Schueppel, Ziegler, and Treves; the endothelial cells of the lymph-spaces by Aufrecht, Hering, and Woodward; the endothelial cells of the blood-vessels and lymphatics, or connective-tissue cells, by Rindfleisch and many of the modern authors. The histological source of

epithelioid cells is manifold. In the synovial membrane they are derived most often from the endothelial cells of blood-vessels, and in bone from the medullary tissue.

The epithelioid cells are the embryonal cells, the product of proliferation from any of the fixed tissue-cells in a tubercular inflammation, and they remain as such until they are destroyed by degenerative changes from the continued action upon them of the bacillus of tuberculosis or its ptomaines, or until some of them become, by hypernutrition, giant-cells; or, on cessation of

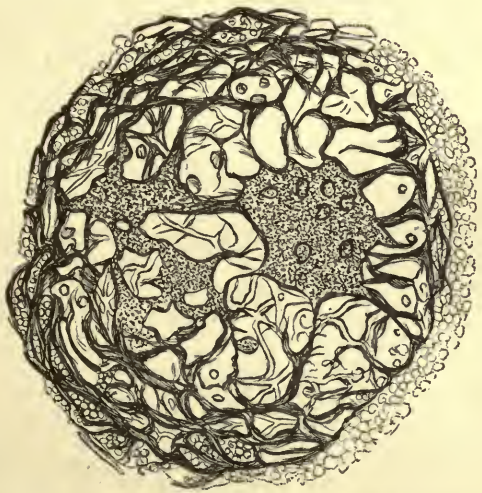

FIG. 10.—MULTINUCLEATED AND BRANCHED CELLS FROM A FINE, GRAY, MILIARY TUBERCLE OF THE LUNG, IN A CASE OF ACUTE TUBERCULOSIS. ×200. (*Green.*)

Wide meshes are seen in the immediate vicinity of the cells, inclosing a few lymphoid elements. The branched processes are directly continuous with the adenoid reticulum of the tubercle.

the primary cause, they are transformed into tissue of greater durability.

Reticulum.—Schueppel first called attention to the reticulated structure of tubercle by his description of the reticular arrangement within tubercles of lymphatic glands. The reticulum, according to most authors, consists of the pre-existing connective tissue pushed asunder by the new cells. According to Wagner, Schueppel, Brodowski, Thaon, and Ziegler, it is made up of protoplasm. Buhl taught that the giant and epi-

thelioid cells secrete a substance at their periphery, which, on becoming firm, is formed into a structure resembling connective tissue. According to his researches, only the marginal zone is supplied with loose, ready-formed connective tissue of the organ.

Wahlberg maintained that the principal reticulum consists of protoplasm which is traversed by a net-work of connective

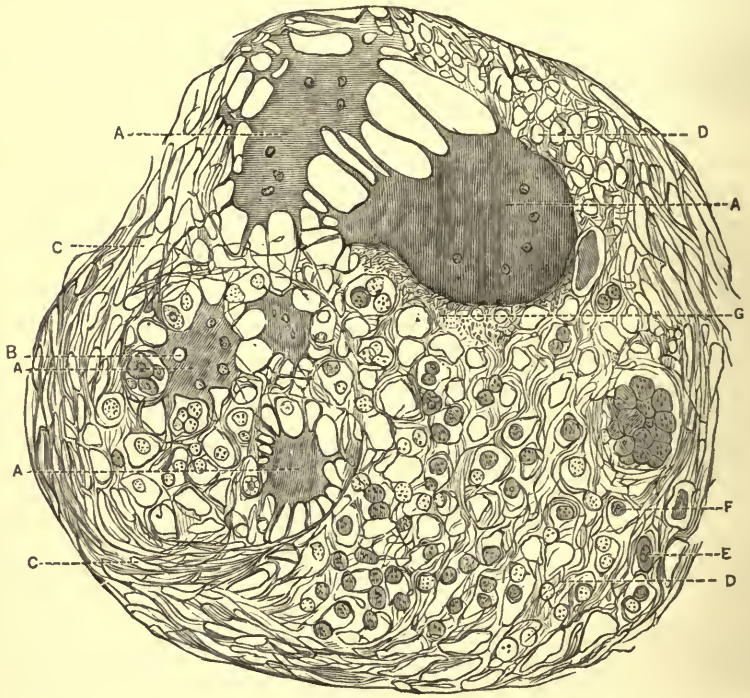

FIG. 11.—FULLY-DEVELOPED RETICULAR TUBERCLE OF LUNG. × 450. (*Hamilton.*)

A, A, A, giant-cells; B, vacuoles in one of them; C, peripheral capsule of fibrous tissue; D, reticulum of the tubercle; E, large, endothelium-like cells lying on the reticulum and within its meshes; F, smaller "lymphoid" cells occupying the same situation; G, peripheral, fibrous-looking border of the giant-cells.

tissue. The reticulum is always more marked in the periphery of the tubercle-nodule, where, from pressure, it is condensed into a fibrous capsule. Watson Cheyne was never able to distinguish a reticulum in tubercle, and he believes what has been regarded as such has been processes of giant-cell, bands of connective tissue, and diffraction appearances due to imperfect illu-

PLATE V.

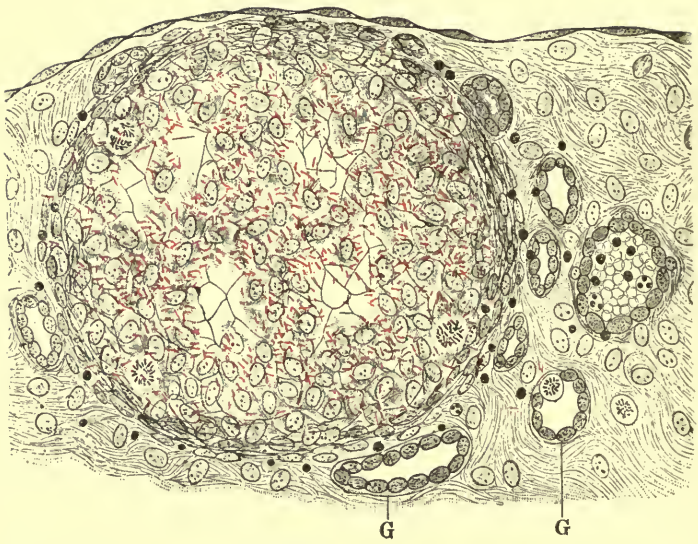

Fig. 12.—Circumscribed Tubercle of Iris, Consisting of Epithelioid Cells. Karyokinetic Changes Observed Only in a Few of the Peripheral Cells. Double Staining. × 950. (Baumgarten.)

mination. Anything like a reticulated frame-work in tubercle can, of course, only be found during the very earliest stage of the tubercular inflammation, before the pre-existing connective-tissue spaces have become obscured by the inflammatory exudation. In the centre of the nodule the connective-tissue frame-work soon disappears, as it takes an active part in the inflammatory process and becomes transformed into epithelioid cells, while toward the periphery it remains for a longer time.

Arrangement of Cells in a Recent Tubercle-Nodule.—The earliest evidences of the formation of a tubercle-nodule, as witnessed under the microscope, is the appearance of small cells, which resemble ordinary embryonal cells, which are the product of tissue-proliferation from a mesoblastic matrix—usually the connective tissue—and its embryological and histological prototype,—the endothelial cells of blood-vessels and lymphatics. (Plate V, Fig. 12.)

From these cells the epithelioid and giant cells are, later, developed. Some of the central cells, by appropriation of a superabundance of food furnished by leucocytes in a state of fragmentation, become hyperplastic, and are transformed into giant-cells; these occupy the centre of the nodule. Around these cells the smaller or epithelioid cells arrange themselves, and between them and in the periphery of the nodule are found the smallest cells,—the leucocytes.

Gaule and Tizzoni distinguish three zones in a tubercle: (1) an external, composed of small round-cells; (2) a lesser, epithelial, or middle zone, containing the reticulum; (3) a central space containing a giant-cell. The structure of a tubercle is not always typical, and hence the division into zones is based more on theoretical grounds than actual observation. The giant-cell is not an essential histological element of tubercle, but an accidental product. In some tubercles giant-cells cannot be found, while in others they are numerous. Giant-cells can only develop from epithelioid cells if the local conditions are favorable for hypernutrition; that is, if the leucocytes, in a condition

of fragmentation, are within their grasp. If they are present they always mark the location of the starting-point of the tubercular infection, as only the older leucocytes undergo this change. The number and size of the epithelioid cells are also subject to great variation, and are further modified by the nutritive conditions within and in the immediate vicinity of the nodule. If cell-proliferation is active the epithelioid cells appear densely packed in the reticulum, nutrition is greatly impaired, and the new cells undergo degenerative changes before they attain their average size. The leucocytes are scattered among the giant and epithelioid cells, and as they reach the part through the inflamed wall of the capillaries in the immediate vicinity they are most numerous in the periphery of the nodule and along the course of the affected vessels. *The product of tubercular inflammation acts as an irritant, and produces an inflammation of a chronic type in its immediate vicinity.*

Blood-Supply of Tubercle-Nodule.—If tubercle is primarily an endovascular product, as is so often the case, its outer wall is fibrous, composed of remnants of blood-vessels, in the interior of which the essential tubercular product can be seen and studied. The blood-vessel, at a point corresponding with the tubercle, becomes obliterated by a tubercular thrombus from the very beginning, and the tubercular tissue is cut off from further blood-supply, as new blood-vessels never form in tubercle. If the tubercle-nodule originates in the paravascular spaces, the cells which accumulate push the vessels apart and form an avascular inflammatory product between them. If a number of tubercles become confluent, the capillary vessels between them are blocked and are converted into tubercular tissue, thus cutting off permanently the blood-supply to the infected area. Some of the old authors were familiar with the defective blood-supply of tubercle. Mr. Stafford ("A Treatise on the Injuries, the Diseases, and the Distortions of the Spine," p. 151. London, 1832); in speaking of scrofulous affections of the vertebræ, in reference to the blood-vessels in and around the foci, says: "If

the bone, as may be seen in some preparations in St. Bartholomew's Museum, be injected with subtle injection in the early stage of the disease, before caseous matter has begun to accumulate, the vessels are seen to ramify freely through the cancelli; but if the injection be made when the cancellous structure has become loaded with this matter, there is still to be seen a degree of vascularity at the line of demarcation between the disease and the sound parts, though the injection has failed to enter the newly-formed matter. From this, we may infer that this deposition is like pus,—a mere unorganized secretion." *The absolute ischæmia of the tubercular product is one of the conditions which determines speedy death of the cellular elements, coagulation necrosis, caseation, and liquefaction of the dead material.*

Distribution of Tubercle Bacilli in Nodule.—The distribution of bacilli in tubercular tissue is peculiar,—the bacilli are either within or between the epithelioid cells, while they are not found beyond the inflammatory zone. In the epithelioid cells they are usually found near or within the nucleus. The disposition of bacilli is seen in the tubercle-nodule and in the tubercular infiltration. The bacilli can be found best by first locating, under a low power, tracts of epithelioid cells. If giant-cells are present, bacilli can be found in their interior in largest number. They are found most numerous among the peripheral zone of nuclei, and arranged in such a manner that the long axis radiates from the centre of the cell. Some of the bacilli are distributed irregularly through the intercellular spaces, isolated or in little groups. (Fig. 6.)

As degeneration of cells takes place the number of bacilli is diminished, and they either cannot be found at all or an isolated bacillus can be detected here and there, on most careful examination. Even in cases where no bacilli can be found in the cheesy material or tubercular pus, these substances retain their infective properties, as numerous inoculation experiments have shown,—a proof that they still contain the bacilli, which,

perhaps, are refractory to the staining process, or the bacilli have disappeared, or, what is more probable, spores have remained, and the propagation of the disease is due to their presence.

Growth of the Tubercle-Nodules.—The typical tubercle-nodule is microscopical in size. The growth of the swelling depends on the formation of new tissue, migration of leucocytes, and confluence of nodules into larger masses. The bacillus of tuberculosis, when brought in contact with fixed tissue-cells susceptible to its pathogenic action, incites tissue-proliferation, which always takes place by karyokinesis. Baumgarten's investigations leave no doubt that epithelioid cells constitute the entire mass of the forming tubercle. (Fig. 12.) He has also observed karyokinetic figures in tubercular tissue in cells derived from the connective tissue, endothelia, and epithelia. Each tubercle-nodule increases in size by the growth of new cells from pre-existing tissue, and, as the primary cause—the bacillus of tuberculosis—multiplies in the tissues, bacilli are conveyed into the surrounding tissues by leucocytes or the plasma-current, and new centres for tubercle formation are established, which, later, become confluent, forming masses of considerable size, the numerous foci of caseation corresponding to the centres of so many nodules. The growth of tubercle is favored by local and general conditions, which diminish tissue-resistance, while retardation takes place, in consequence of degenerative changes in the cells of which it is composed, or, if the cells are converted into tissue of a higher type, from disappearance or suspension of activity of the primary cause. The anatomico-pathological conditions which characterize tubercle put a limit to its growth, and further increase in size of the swelling takes place by confluence and the formation of new centres of infection in a peripheral direction.

CHAPTER V.

Histogenesis of Tubercle.

The histological source of the inflammatory product was determined nearly fifty years ago by Virchow, who traced the cell-proliferation to the connective-tissue cells. Histological researches since that time have added but little to our knowledge of the histogenesis of tubercle. *The connective tissue is the principal histological source of the cellular elements of the tubercular product, irrespective of the anatomical location of the inflammation.* It appears that the bacillus of tuberculosis exercises a special predilection for the connective-tissue cells. While the connective-tissue proliferation furnishes the bulk of the inflammatory product in every tubercle-nodule, in whatever part or organ this may be found, it is now generally conceded that the pathogenic action of the tubercle bacillus is not limited to the connective-tissue cell alone, but that other mesoblastic tissues are affected in a similar manner, and contribute to a lesser extent to the building up of the tubercle-nodule. Endothelial cells and lymphoid structures in different organs not infrequently are the primary seat of the tubercular inflammation, and, when excited to tissue-proliferation by the presence of tubercle bacilli, furnish the first material in the construction of the tubercle-nodule. Bastian observed tubercle-nodules upon the small vessels in cases of basilar meningitis, but refers their origin not to proliferation of the nuclei of the endothelial lining of the vessels, but to new cells springing from the endothelial cells of the paravascular lymphatic sheaths which surround the vessels of the meninges of the brain. Knauff demonstrated the lymphoid character of the adventitia by examining the capillary vessels of the visceral pleura in dogs which had been exposed for a long time to an atmosphere impregnated with coal-dust. He found the pigment-granules lodged in small masses close to the walls of small arteries and veins. Examining the same vessels in other dogs not thus treated, he found, upon the outer

surface of the adventitia, opaque, whitish-gray nodules, surrounded by round and oval cells containing nuclei; also, lymph-corpuscles. The same structures, which he named lymph-nodules, are also found around the same vessels of the pleura in man, and Knauff looks upon these lymphoid structures as the starting-point of tubercular inflammation. Klebs maintains that the endothelial cells of lymphatic vessels are the most frequent location for the formation of the primary tubercle-nodule. He observed that in cases of tubercular ulceration of the intestines the peritoneum is reached through the lymphatic vessels.

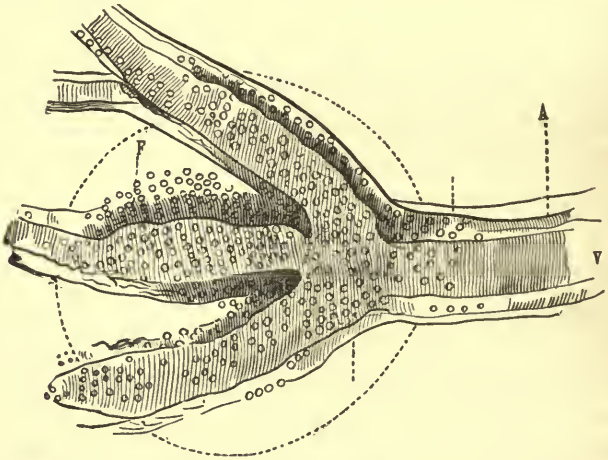

FIG. 13.—MILIARY TUBERCLE IN THE PIA MATER. ×100. (*Cornil and Ranvier.*)
The dotted line indicates the original size of the tubercular nodule; A, the lymphatic sheath; V, the blood-vessel; F, proliferation of elements within the sheath.

Silver-stained preparations of inoculation-tuberculosis in rabbits showed that the most recent products occurred in the interior of the lymphatic vessels at points of intersection. In some places the nodules extended into the tissues between the lymphatic channels, but their centre always corresponded to the location of a lymphatic vessel. At some points the nodules were seen to branch out, but these projections, in reality, were within the lymphatic vessels, as the net-work of lymphatic endothelia could be seen above and underneath the tubercular product. Toward the centre of the nodule no endothelial cells could be distin-

guished, and this fact led him to the belief that the endothelial cells are directly concerned in the production of the new tissue. In the mesentery he saw the tubercles adhere to the outer wall of the capillary vessels, and, as the spindle-shaped cells of the outer coat appeared to be pushed apart by the new tissue, he regards the adventitia as a genuine lymphoid structure. Rindfleisch traces the beginning of the process in miliary tuberculosis of the lungs to a proliferation of the endothelia and the external connective-tissue layer of the capillary lymphatic vessels. Manz studied the development of tubercle in the choroid in patients suffering from general miliary tuberculosis. So constantly does this disease show itself in this structure that von Graefe, Cohnheim, Fränkel, and Bouchut recommend ophthalmoscopic examination as a diagnostic measure in cases of suspected general tuberculosis. Manz traces the commencement of the disease in the choroid to cell-proliferation in the tunica adventitia of the small vessels. The process is, however, not limited to this structure; the non-pigmented stroma-cells may also assist in furnishing material for the new product. Bart, on the other hand, asserts that the vessels, in cases of tuberculosis of the choroid, are not primarily affected; according to his observation, the process depends exclusively on a degeneration of the stroma-cells, as the remaining tissue did not appear to be affected.

Cohnheim, Ziegler, and others maintain that the leucocytes furnish most of the material in the building up of the tubercle-nodule. This idea is no longer tenable, as the tubercle bacillus, when brought in contact with fixed tissue-cells, is known to cause active cell-proliferation, while it does not produce a sufficient alteration in the walls of blood-vessels to enable free cell-migration to take place. At the last meeting of the International Medical Congress, Ziegler announced that he had changed his ideas in reference to the function of leucocytes, and that he is now a firm believer in the origin of inflammatory tissue from pre-existing fixed tissue-cells. As a constant pathological condition, we also find, in every tubercle-nodule, early

disappearance of most, if not of all, of the capillaries,—a condition unfavorable to cell-migration. The foundation for every tubercle-nodule is laid by cells derived from the fixed tissue-cells, the presence and number of leucocytes being accidental, depending upon the number of capillary vessels within and in the immediate vicinity of the nodule, and the intensity of alteration of their walls, induced by the irritation caused by the presence of tubercle bacilli and the inflammatory product furnished by the fixed tissue-cells. *In bone, the medullary tissue, being a lymphoid structure, is acted upon by the tubercle bacilli, and furnishes the corpuscular elements of the inflammatory product, if the process is extra-vascular, while the endothelial cells and connective tissue of the blood-vessels are the structures first acted upon in tubercles of this structure of endovascular origin. In primary tuberculosis of joints the synovial membrane is first affected, and the process extends from here to the subjacent cartilage and bone.* Experiments on animals, as well as microscopical examinations of pathological specimens, have sufficiently demonstrated the fact that the tubercle-nodule in bones and joints, as well as in other organs, is nothing more nor less than a circumscribed inflammatory product, the histological elements of which are composed, for the most part, of new tissue, formed by proliferation of fixed tissue-cells, which have been acted upon by the bacillus of tuberculosis, or its ptomaines. The specific pathogenic effect of the bacillus consists in its power to cause a chronic inflammation of the tissues with which it has been brought in contact. *The tissues primarily affected are the cells which are nearest the essential microbic cause, irrespective of their embryological origin, their histological structure, or physiological function. The mesoblastic tissues are the primary starting-point of the tubercular process, in the majority of cases, for the reason that it is here that localization of the tubercle bacillus takes place most frequently.* In cases of inoculation-tuberculosis, the primary nodule develops at the point of insertion of the virus from connective-tissue proliferation, and from

here the bacilli enter the lymphatic channels, and the secondary nodules are composed of cells derived from the endothelial, lymphoid, and connective-tissue cells which compose these structures. If the bacilli are injected in sufficient quantity directly into the circulation, or gain entrance into the blood-current from some tubercular focus, they become implanted upon the wall of distant capillary vessels, and the nodule which forms at the seat of implantation consists of cellular elements formed by the tissues of the vessel-wall. As soon, however, as bacilli reach the extra-vascular tissues, they, in turn, furnish their part of the material for the further growth of the nodule. If the tubercle bacillus become implanted upon a mucous surface,—as the bladder, intestines, nose, larynx, uterus, etc.,—if such surface is susceptible to tubercular infection, the epithelial cells take an early and active part in the inflammatory process. *From the manner of entrance into and diffusion through the tissues, it is apparent that the mesoblastic tissues, especially the connective tissue and endothelial cells, being the first to become infected, furnish the greatest amount of the new material in most tubercular lesions; but all tissues, when infected, take part in the process.*

CHAPTER VI.

Caseation.

The gray or miliary tubercle is transformed into the yellow, crude, or cheesy tubercle by a process which is called *caseation*, or *tyrosis*. The exact nature of this process remains unknown. The cheesy material is composed of the products of cell-necrosis. *Early death of cells is the most characteristic pathological feature of tubercle, which distinguishes it from all other forms of chronic inflammation.* Two causes can be advanced to explain this peculiar and almost pathognomonic form of degeneration, which occurs, almost without exception, in every tubercle, if a sufficient length of time has elapsed: (1) inadequate blood-supply; (2) specification of the bacillus of tuberculosis or its ptomaines. Caseation always commences in the centre of a nodule, consequently at a point most remote from the vascular supply, and in cells which have been exposed longest to the deleterious effect of the primary microbic cause. Tubercle is a non-vascular product. From causes which as yet are not fully understood, vascularization of the nodule never takes place. *The angioblasts in the infected area are transformed into epithelioid cells that have lost permanently their intrinsic anatomical structure and physiological function.* Nodules which have primarily an intra-vascular origin are rendered avascular by closure of the vessel from intra- and peri- vascular cell-proliferation. If the primary starting-point of the nodule is outside of the vessels the rapidly-accumulating cells exert pressure upon the surrounding vessels, and thus diminish the blood-supply to the part affected. The new cells require an adequate quantitative and qualitative blood-supply for their further development, and if this fail to take place, as is the case in every tubercular product, they necessarily suffer from malnutrition, and undergo degenerative changes at an early stage of their existence. A deficient blood-supply, in the absence of other more specific causes, would result in fatty degeneration; *but caseation is*

something different from ordinary fatty degeneration, and the bacillus of tuberculosis or its ptomaines must be regarded as its immediate and essential cause. Caseation is preceded by coagulation necrosis, which is one of the results of the specific action of the bacillus on the tissues. *The coagulation necrosis commences in the giant-cells and in the epithelioid cells in the centre of the nodule, and caseation follows as soon as the dead cells have lost their histological identity and appear under the microscope as a débris, in which no distinct cell-forms can be identified.* Caseation is attended by softening, which can be readily recognized in tubercular masses, the size of a hazel-nut to that of a walnut, composed of numerous confluent nodules, with as many caseating foci. In such masses the small, cheesy foci become confluent and form larger caseous centres. Caseation proceeds from the centre of each nodule toward the periphery, layer after layer of epithelioid cells being destroyed and changed into cheesy material. The part of a tubercle-nodule which has undergone caseation contains few or no bacilli, and yet inoculation experiments show it to be highly infectious. The cheesy material does not furnish the proper nutrient material for the growth and development of the bacillus, which dies from starvation, while the spores, being more durable and possessing greater power of resistance, remain in an active condition for an indefinite period of time in the caseous material, and it is due to their presence that infection takes place from old, cheesy foci, and that successful inoculations can be made with cheesy material. While the disease has become arrested in the centre of a nodule, with the appearance of caseation, its growth in a peripheral direction pursues the same relentless course. The bacilli multiply in fresh tubercular tissue, and are carried beyond the peripheral zone into the surrounding tissues, where new, independent foci of infection are established, which, in the course of time, pass through the same series of pathological changes as the primary nodules. It is a well-known clinical fact that acute miliary tuberculosis is not a primary affection,

as in all such cases a careful post-mortem examination will reveal the presence of a cheesy focus in a lymphatic gland, the lungs, testicles, a joint, or bone, or some other organ from which the general infection occurred. A cheesy mass is, therefore, always a source of danger, as it may become the distributing-point of the essential cause of tuberculosis, and produce general miliary tuberculosis years after the local disease has been arrested. The cheesy material may lie latent for twenty to fifty years as long as it remains firm and encysted, but as soon as it undergoes softening and liquefaction the spores which it contains can be taken up by the blood-vessels and become then the cause of general infection.

CHAPTER VII.

Tubercular Abscess.

The pathogenic effect of the bacillus of tuberculosis on the tissues is to produce a chronic inflammation, which invariably results in the production of granulation tissue. The embryonal cells furnish, as it were, a wall of protection for the time being for the surrounding healthy tissue. The characteristic pathological feature of every tubercular product consists in the tendency of the cells of which it is composed to undergo early degenerative changes, which are caused by local ischæmia and the specific chemical action of the ptomaines of the tubercle bacilli, and consist in coagulation necrosis, caseation, and liquefaction of the cheesy material into an emulsion, which has, until quite recently, always been regarded as pus, until modern researches have shown that it is simply the product of retrograde tissue metamorphosis, and not *true pus*. I believe that it can now be considered as a settled fact that the bacillus of tuberculosis is not a true pyogenic microbe, and that in the absence of other microbes it produces a specific form of chronic inflammation, which invariably terminates in the formation of granulation tissue; *and that, when true suppuration does take place in the tubercular product, it occurs in consequence of secondary infection with pus-microbes.* The earliest commencement of such an abscess is a small nodule, which slowly increases in size to that of a walnut, when softening takes place in the centre by degeneration and liquefaction of the inflammatory product. The solid mass at first is composed of confluent tubercles. Liquefaction of the caseous material takes place by imbibition of fluids. In the walls of the primary abscess new foci liquefy, and thus, by increase of the liquid contents of the first cavity, and by the addition of new spaces, the abscess-cavity is enlarged to the enormous dimensions so frequently met with at the bedside in the treatment of tubercular affections of bones and joints.

At the last meeting of the French Congress of Tubercu-

losis (1891), Hallopeau stated his belief that cold abscesses are caused by chemical products of the tubercle bacillus independently of the microbes of suppuration proper.

Arloing diminished the virulence of the tubercular virus by heating, and produced with it limited suppuration,—a result which agreed with the statement previously made by Koch. Verneuil and Beretta spoke of the transformation of cold or chronic into hot or acute abscesses, a change which is occasionally observed in tubercular lesions, and which they attribute to the presence and action of pyogenic microbes, especially the streptococcus. In their experience such a change always resulted in a cure, whether the abscess opened spontaneously or was incised. They maintain that the pus-microbes destroy the tubercle bacillus. The so-called tubercular, congestive, wandering, or cold abscess contains a fluid which, macroscopically, resembles pus, but which, when examined under the microscope, shows none of its characteristic histological elements.

Chemical Analysis.—Lannelongue ("Abscès froids et tuberculose osseuse." Paris, 1881), in comparing the pus contained in cold abscess with the *pus bonum*, calls attention to the fact that the former contains a much lesser quantity of solid constituents, and the quantity of albumen is correspondingly less. He gives the following result of a chemical analysis of tubercular pus:—

Serum (949.30).		*Solid Ingredients* (50.70).	
Mucin,	13.82	Pus-corpuscles,	5.16
Serum-albumen,	25.57	Cholesterin, Lecithin,	1.03
Metalbumen,	13.07		
Cholesterin,	4.50	Inorganic salts,	0.52
Leucin and similar substances,	7.25	Water,	43 87
Inorganic salts,	6.44	Undetermined substances,	0.12
Water,	877.20		

If such a chronic cold abscess is converted into an acute hot abscess, it is almost positive proof that a secondary or mixed infection with pus-microbes has occurred. Tubercular

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pus can usually be distinguished from ordinary pus, without much difficulty, by its macroscopical appearances. Tubercular pus, so-called, is an emulsion which presents a whitish or almost chalky appearance, in which minute fragments of dead tissue and shreds of fibrin are suspended, while ordinary pus is a homogeneous fluid, of the consistence of thin cream, presenting a yellowish appearance, with a tinge of green. If the bacillus of tuberculosis meets with sufficient resistance on the part of the surrounding tissues, it finally exhausts the nutrient material in the granulations and dies, or remains in a latent condition; the sterile granulation material is converted into cicatricial tissue and the local lesion is cured. The cases in which the tubercular product is removed by cicatrization terminate most frequently in spontaneous cure. If, on the other hand, bacilli in sufficient number are present to destroy the granulation cells, coagulation necrosis, caseation, and liquefaction of the infected tissue take place; a spontaneous cure is still possible if a part of the fluid portion is absorbed and the solid *débris* becomes encapsulated. The same favorable termination is expedited, under similar circumstances, if the primary lesion has healed and the inflammatory product is removed by operative interference, under strictest antiseptic precautions; or if, at the same time, the primary focus can be completely removed by extending the operation to the primary lesion. Secondary infection of a tubercular product with pus-microbes, without a direct *infection atrium*, is possible, although practically a very infrequent occurrence, and, if the primary lesion is located in an unimportant organ, and in such a place where the inflammatory product can be reached at an early stage, or can be eliminated spontaneously, a cure is often effected, as the suppurative inflammation frequently proves successful in destroying all of the tissues inhabited by the bacillus, and the whole nidus, with the microbes it contains, is eradicated permanently from the body. Such a course is not seldom observed in cases of tuberculosis of the lymphatic glands of the neck. If, however, the tubercular process affect

important organs, or parts deeply located, with extensive infection of tissue, and secondary infection with pus-microbes takes place, then the patient incurs the danger of septic infection and local and general dissemination of the tubercular process, from the breaking down of the protective wall of granulation tissue.

Garrè has shown that pus-microbes grow luxuriantly in the soil furnished by a tubercular abscess, while they do not grow in ordinary pus. Watson Cheyne states that liquefaction of the tubercular product is determined by the constitution of the patient, as it occurs most frequently in persons in whom the disease is hereditary. That the bacilli do not multiply in a tubercular abscess has been definitely settled by Schlegtendal. He examined 520 specimens of fluid taken from tubercular abscesses, and found bacilli present in only 75 per cent. Garrè ("Zur Ætiologie der kaltenabscesse, Drüseneiterung, Weichtheil u. Knochen Abscesse u. der tuberculösen Gelenkeiterungen." *Deutsche Med. Wochenschrift*, B. xxi, No. 34, 1886.) has also made an extended series of observations to ascertain the presence of the bacillus in cold abscesses. He examined the contents of tubercular abscesses in thirty cases, and only seldom found bacilli. Cultivation experiments proved usually also negative, but inoculations yielded always positive results. He believes that tubercular pus contains many active spores after the bacilli have disappeared. According to this author, many tubercular ulcerations and abscesses are the result of a mixed infection, as has been claimed by Hoffa for some cases of empyema complicating pulmonary or pleural tuberculosis. In cold abscesses, and in the liquefied, cheesy material of tubercular cavities in bones and joints, no pus-microbes could be found, not even in cases that pursued a rapid course. Cultivations made with such material remained sterile, while inoculations produced typical tuberculosis in animals. Specimens of such fluid, examined under the microscope, showed none of the morphological elements of pus, but were seen to consist of an

emulsion of fat-globules and *detritus* of broken-down tissue, suspended in serum. Garrè believes it is possible that, in many cases of suppuration following in the course of a tubercular process, pus is the result of a mixed infection, and that the pus-microbes disappear before the examination is made.

Tavel ("Beitrag zur Ætiologie der Eiterung bei Tuberculose. Separat Abdruck aus den Beiträgen zur Chirurgie. Festschrift, herausgegehen zu Ehren des Professor Kocher in Bern., 1891") has made, recently, a valuable contribution to the etiology of suppuration in tubercular lesions. In his classification of suppuration Verneuil has divided pus into "*mono- et poly- microbique*," and brings tubercular pus under the latter head, as he believes it is the product arising from the action of both tubercle bacilli and pus-microbes.

Garrè, Krause, and Steinhaus are of the opinion that tubercular pus is in reality no pus, but simply the product of cellular disintegration brought about by the bacillus of tuberculosis. G. Roth and de Ruyter regard tubercular pus as the product of a mixed infection following invasion of a tubercular product with pus-microbes. In the Berlin Hygienic Institute experiments made with Koch's lymph showed that large quantities injected subcutaneously in animals produced a circumscribed suppuration, which appears to demonstrate that the chemical products of tubercle bacilli possess mild, facultative, pyogenic properties. Inoculation experiments almost invariably result in the formation of an abscess at the point of inoculation, and the pus contained no other microbes besides tubercle bacilli. It has recently, also, been shown that syphilitic gummata and actinomycotic foci may become the seat of suppuration without an additional infection, and at the same time the pyogenic properties of the bacillus of glanders has been demonstrated. The typhoid bacillus, the gonococcus, the pneumococcus, the microbe of scarlatina, and the anthrax bacillus are known to cause, at least occasionally, suppuration. Tavel studied the contents of tubercular abscesses by means of stained preparations

under the microscope, by cultivation and inoculation experiments, taking special precautions to prevent contamination of the material after its removal from subcutaneous tubercular lesions. In the selection of cases special pains were taken to study those which pursued a subacute course in which the suspicion of the existence of a mixed infection could be entertained. In all, forty cases were subjected to a critical examination as to the presence of mixed infection, and in all of these a positive or probable diagnosis of tuberculosis was made before the operation. In the first thirty cases of tubercular abscess the exclusive presence of the tubercle bacillus was demonstrated by inoculation experiments and the clinical course of the lesions from which the material was obtained. In the first five cases the results of the inoculation experiments and the clinical course proved the tubercular nature of the lesions. Besides tubercle bacilli, streptococci or staphylococci were found in the cases of mixed infection. The hæmatogenetic origin of this mixed infection could be excluded, as in all cases a connection could be found between the focus and the external or internal surface of the body. In the last five cases, in which he demonstrated hæmatogenetic infection with the streptococci and staphylococci, and in which the clinical course before the operation spoke for tuberculosis, the subsequent course, as well as inoculation experiments, showed that they were *mono* infections, and that here the tubercle bacillus was out of question. From these experiments and clinical observations, he came to the conclusion that the mixed infections with a hæmatogenetic origin are exceedingly rare. In most of the cases of mixed infection some connection with the surface of the body can usually be demonstrated. The author is of the same opinion as Garrè, that tubercular abscesses are caused exclusively by the tubercle bacillus; but, unlike Garrè, he believes that the process is the same, or at least very similar, during the early stages of a tubercular affection, and in acute cases, as in acute suppurative inflammation, attributing to the chemical products of tubercle

bacilli mild pyogenic properties. According to the author, the leucocytes and embryonal cells of the inflammatory product of the fixed tissue-cells are first transformed into pus-corpuscles, and that these undergo later fatty degeneration, and, after complete disintegration, furnish the granular *detritus* which has been regarded as the characteristic part of tubercular pus. As the greatest difference between pus-corpuscles in acute and tubercular abscesses, he regards a more speedy granular degeneration and disintegration of the latter. A tubercular abscess is always lined by a tubercular membrane, which contains the typical structure of the tubercular lesion and the primary and essential cause of the inflammation,—the bacillus of tuberculosis. The tension in such abscesses is much less than in abscesses caused by acute phlegmonous suppuration, and on this account fluctuation is a well-marked symptom in most cases.

Lannelongue ("De la tension dans les abscès Tuberculeaux." *Bull. de la Soc. de Chir.*, December 23, 1886) examined, by means of a modified Ludwig hæmo-dynamometer, the degree of tension in tubercular abscess of the extremities, and found it, as a rule, equal to the blood-pressure in veins between 12 and 22 millimetres. Only in abscesses of the wall of the thorax was the tension higher in consequence of respiration-pressure, which increased it to 30 to 50 millimetres. During continued extension with 3 kilogrammes' weight, and after injection of iodoform ether, the pressure was increased in former instances to 60 millimetres, and in the latter case 50 to 80 millimetres, mercury-pressure. The thickness of this membrane depends on the length of time the abscess has existed and the duration of the infection. This membrane is formed by the extension of the tubercular process from the primary starting-point to the surrounding tissues. The color of the membrane is yellowish gray or grayish violet. It is, on an average, a few millimetres in thickness and loosely attached to the subjacent tissues. This membrane is the most characteristic anatomical feature of every tubercular abscess, as

it is never found in any other abscess, and bears a very strong resemblance to the wall of an echinococcus-cyst. It consists of fragile tissue, which is composed essentially of heaps of miliary tubercles. Between the tubercles, and upon the surface of the membrane, masses of coagulated lymph can be found. If the membrane is rich in tubercles it presents somewhat the appearance of frogs' spawn.

The surface is often dotted with yellowish spots, each one

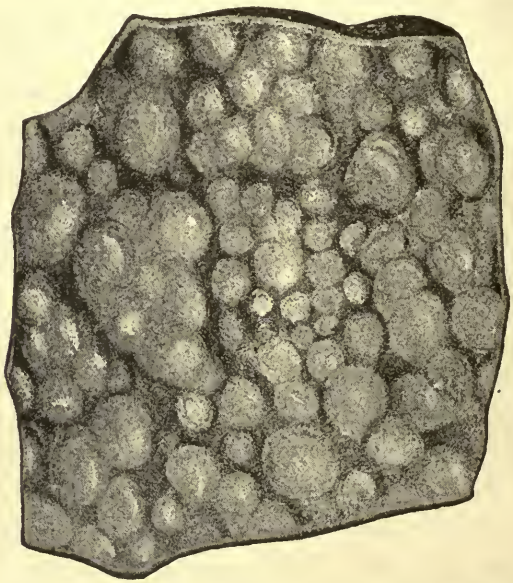

FIG. 14.—ABSCESS-MEMBRANE FROM A TUBERCULAR ABSCESS. Surface view, slightly enlarged. (*Volkmann.*)

of which is a caseation-centre. At times such abscess-cavities are spanned by strings of connective tissue, which are also covered with tubercles, and when torn or cut, during the operative treatment of the abscess, often give rise to troublesome hæmorrhage. In scraping out such abscesses with a sharp spoon the greatest caution must be exercised to remove every particle of the membrane, as incomplete removal, almost without exception, is followed by relapse. Often, after thorough scraping, examination will reveal islets of tubercular tissue, which must

be removed separately. After spontaneous evacuation of a tubercular abscess, or after incomplete removal of the infected tissue, a tubercular fistula forms. Such fistulæ are always lined with soft granulations, which appear in a wonderfully short time. The softness, pallor, and œdematous appearance of these granulations, lining the tract and opening of such fistulæ, distinguish these granulations from syphilitic and osteomyelitic inflammatory products in similar tissues and localities. In exceptional cases the tubercular infiltration from the abscess-wall extends to the muscles, which then become the seat of a typical tubercular myositis. Such abscesses often travel great distances; for instance, from the bodies of the vertebræ down to and below Poupart's ligament. The entire track over which they have passed is lined by the tubercular membrane, the abscess and the primary lesion being connected with an uninterrupted path of tubercular tissue. The infection follows the migration of the abscess, in whatever direction that may take place. If an additional infection from without take place, following either a spontaneous discharge or after incision, the superficial granulations are destroyed by the suppurative process which is initiated, exposing the patient to the additional risks of septic infection and a more rapid local and general dissemination of the tubercular process.

Symptoms and Diagnosis. — The tubercular abscess is called a cold abscess because it lacks the characteristic clinical phenomena which attend the development of an acute or hot abscess. There is but little, if any, rise of the local temperature, and, unless the abscess has reached the skin, the surface looks rather preternaturally pale than red, *and the abscess itself is always painless, and not tender on pressure. The pain, if present, is referred to the primary seat of the tubercular inflammation.* Fluctuation is usually well marked, as the tissues around the abscess are not much infiltrated. The most important clinical feature of a cold abscess is its tendency to migrate from the place where it originated to distant localities by gravi-

tation; hence the name given to it by German writers,—Senkungsabscess. Thus, in tubercular spondylitis, the abscess may appear in the lumbar region, and is then called *lumbar abscess;* it may follow the iliac muscle and appear in one of the iliac regions, and is then, from its location, termed *iliac abscess;* or, finally, it may follow the psoas muscle and appear above or below Poupart's ligament, when it constitutes a *psoas abscess.* In tuberculosis of the hip-joint the abscess appears posteriorly underneath the gluteal muscles, if perforation of the capsule take place in this direction; or it appears anteriorly, usually a considerable distance below the hip-joint, if perforation of the capsule has taken place in an opposite direction. As the contents of the abscess carry the original cause of the disease, infection of the tissues takes place along the whole course traveled by the abscess, which is always lined with infected granulation tissue. Although the primary cause of a tubercular abscess is most frequently tuberculosis of a bone or joint, it can also develop in the course of any localized form of tuberculosis, and it is quite frequently met with in the course of tuberculosis of the lymphatic glands. One of the largest tubercular abscesses in the iliac fossa that ever came under my observation formed in the course of two weeks after extirpation of a tubercular testicle. The affection of the spermatic cord extended beyond the internal inguinal ring, and the part not removed undoubtedly served as the starting-point of the abscess. The diagnosis must be made with special reference to the nature and location of the primary lesion. In tuberculosis of the spine, the fixed pain in the region of the affected vertebræ, radiating from here in the direction of the nerves, taking their exit from the affected part on each side, is an important symptom, and this symptom is always aggravated by flexion and alleviated by extension of the spine. In coxitis the pain in the beginning of the disease, especially in the osseous form, is usually referred to the inner aspect of the knee-joint, and is always increased by motion of the hip-joint, and by making pressure over the tro-

chanter in the direction of the axis of the neck of the femur. In cold abscess caused by glandular tuberculosis, the clinical history will point to a chronic inflammation of the glands which preceded the formation of the abscess. Fluctuation is usually a well-marked symptom. As soon as the abscess reaches the skin, that structure becomes inflamed, red, and more and more attenuated by pressure and inflammation, until spontaneous perforation takes place at a point subjected to greatest pressure. If a tubercular abscess become the seat of a secondary infection with pus-microbes, the subsequent symptoms, local and general, are suddenly changed, and are then those of an acute suppurative inflammation. The temperature — which was normal, or nearly so—increases, and presents the daily curves characteristic of acute suppuration and the general symptoms arising from it are those of septic infection, while the abscess, which has been heretofore painless, becomes painful, hot, and tender on pressure; in fact, the clinical picture indicates that a chronic inflammation has been supplanted by an acute one. If any doubt remain as to the character of the swelling and the nature of its contents, this can be dispelled at once by resorting to an exploratory puncture. In cold abscess the fluid removed presents the appearance of serum in which minute particles of broken-down tissues are suspended, while in an abscess caused by a mixed infection it presents the macroscopical and microscopical appearances of true pus.

Prognosis.—The danger attending tubercular abscess must be estimated by the extent and location of the primary disease, the presence or absence of secondary infection, and the general condition of the patient. An open tubercular abscess, which has become infected with pyogenic microbes, and which communicates with an important bone or joint, is always a serious source of danger to life. Such a condition is also unfavorable, in reference to successful surgical treatment, in obtaining a satisfactory functional result. The treatment by iodoformization holds out little encouragement in securing a permanent result, and operative

treatment usually becomes an urgent necessity. If suppuration has given rise to organic disease of any of the important internal organs the prognosis is always grave, as the removal of the primary cause by operative treatment will not prove successful in averting a fatal termination from the complicating lesions. Tuberculosis in other organs renders the case almost necessarily fatal. If the general health remain unimpaired, even an extensive local tubercular disease may be amenable to a spontaneous cure or successful surgical treatment. On the other hand, a tubercular abscess developing in the course of an insignificant and unimportant local lesion occurring in an anæmic person, the subject of incipient multiple foci in different organs, must be regarded as a most formidable condition, with little or no prospects of a favorable termination. From quite an extensive clinical experience with cases of tuberculosis of bones and joints, *I have learned to regard pronounced anæmia as an unfavorable symptom in the different forms of surgical tuberculosis, as it is often an expression that general infection has occurred or that important internal organs are the seat of serious organic changes.* Another important matter to be taken into consideration in making a prognosis, in cases in which general infection can be excluded, is the possibility of eradicating the primary lesion by operative interference. If the disease is so located that this can be done, the chances of successful treatment of the local disease are much better than if the opposite is the case; at the same time, the complete removal of the infected tissues is the best possible guarantee against general infection. Other things being equal, the prognosis is better in patients without a hereditary history of tuberculosis, and in young subjects than those advanced in years.

Treatment.—Patients suffering from suppurating tubercular cavities require nutritious food, ale, porter, or some of the substantial wines, as Tokayer, Aussbruch, port, or sherry; out-door air will often prove the best tonic. Change of residence to the country, the sea-shore, or some mountain-resort has often been

known to effect a cure when recovery was despaired of as long as patients lived in less favorable localities. In the way of medication the treatment must be purely symptomatic. Appetite is restored by the use of bitter tonics; anæmia is treated by the administration of some mild preparation of iron, as the syrup of iodide of iron, tincture of chloride of iron, albuminate of iron, or citrate or tartrate of iron. If codliver-oil is given, it should be administered pure, and not in emulsion, and never upon an empty stomach. Möller's pale Norwegian oil is the best and most palatable. It can be given floating upon any agreeable menstruum, such as black coffee, brandy, whisky, or wine. The best time to administer the drug, without disturbing the digestion, is an hour or an hour and a half after each meal, in doses of from a teaspoonful to a tablespoonful, according to the condition of the digestion and the age of the patient.

Tapping of Abscess, Followed by Antiseptic Irrigation and Subcutaneous Iodoformization.—This method of treatment will be more fully described in another part of the book, to which the reader is referred. This treatment has been followed by most signal success in the treatment of tubercular abscesses, and should invariably receive a faithful trial before operative measures are resorted to. The procedure should be repeated every two weeks until the abscess-cavity has become obliterated. Washing out of the cavity with a 4-per-cent. solution of boracic acid prior to the injection of the iodoform emulsion is of great importance and value, as it secures more thorough removal of the dead, broken-down tubercular tissue, thus bringing the cavity in a more favorable condition for the antibacillary action of the iodoform. If the treatment prove successful, re-accumulation takes place more slowly and the character of the tubercular pus changes. As soon as an active reparative process has been initiated the granulations lining the cavity no longer undergo caseation, and the fluid removed at this time is scanty and resembles mucus more than pus. In a number of cases that have come under my observation I have found, after the

second or third injection, a moderate swelling, which presented well-marked fluctuation, but which, when punctured, yielded no fluid. The swelling and fluctuation were evidently due to the presence of a mass of granulation tissue, which was undergoing transformation into permanent tissue. I have always, in such cases, made the iodoform injection, and in a few weeks the abscess was found healed, and the swelling gradually disappeared. In open, suppurating, tubercular abscesses this treatment has not proved as successful as in cases of uncomplicated, subcutaneous, tubercular lesions. If iodoformization is to be employed in such cases it should be preceded by measures directed toward the suppuration, and thus remove the cause and inflammatory products of the secondary infection. Incision, scraping of inner surface of abscess-wall, and thorough application of peroxide of hydrogen will answer these indications most effectually. After the abscess has been rendered aseptic by such treatment, iodoformization is to be made in the same manner as in closed tubercular cavities. The most rigid antiseptic precautions must be observed in order to prevent a new infection with pus-microbes.

Incision and Removal of Infected Tissue by Scraping.—In all cases where, from the anatomical location of the primary lesion, it is possible to remove the tubercular product by operative interference, and the patient is free from other tubercular affections and other fatal complications, a radical operation is always indicated after simpler measures have failed in curing the primary affection. In such cases the abscess-cavity is laid freely open in a direction which will secure most ready access to its interior with least injury to surrounding parts. Whenever it is found possible, from the anatomical relations of the parts, the incision should be made large enough to expose for direct treatment the whole of the interior surface of the abscess. After the abscess has been incised, its contents are washed away by irrigating with an aqueous solution of iodine, after which the granulations lining the cavity are scraped out with a large,

sharp spoon, and the primary lesion is removed in a similar manner. In dealing with such cavities, it is important not to forget that the tubercle bacilli are contained in the granulations, because if these are not completely removed the principal object of the operation—removal of the primary cause—has not been accomplished, and a return of the disease is to be expected. In many instances prolongation of the tubercular membrane between the interspaces of muscles and tendons renders it necessary to look carefully for such side-tracks and clear them of tubercular material with the sharp spoon. If the abscess communicate with a primary focus in a bone, it is advisable to resort to ignipuncture of the bone after the cavity has been cleared of the granulations with the sharp spoon. The wound is to be closed in the usual manner after iodoformization of the whole surface, leaving only a small opening at the most dependent point for drainage. The scraped surfaces are now in the same condition for primary union as a recent aseptic wound, and, if kept in accurate apposition by the antiseptic dressing, which answers at the same time the purpose of an elastic compress, primary union throughout is frequently obtained. Abscesses which have opened spontaneously, or during the treatment of which infection has occurred, must be treated on the same principles as acute abscesses. As far as can be done, the suppurating granulations should be removed with the sharp spoon, and after disinfection and iodoformization efficient tubular drainage established, and, if the ultimate object is not attained by the first operation, frequent antiseptic irrigations are to be subsequently made until the cavity has been rendered aseptic. Landerer has recently called attention to the value of balsam of Peru in the treatment of tubercular abscesses. He maintains that this drug acts beneficially by stimulating the tissues to renewed activity; thus neutralizing indirectly, at least to a certain degree, the pathogenic effect of the bacilli, while at the same time it hastens the process of repair by its stimulating action on the tissues. In the treatment of open, suppurating,

tubercular surfaces this drug should be tried as a local application. As a fluid for irrigation, under the same circumstances, nothing can surpass the efficacy of a strong, aqueous solution of tincture of iodine. Rest is an important element in the treatment of tubercular abscesses, irrespective of their location. Prolonged confinement in bed and room should be avoided, and rest secured by appropriate mechanical support while the patient enjoys the benefit of out-door air and exercise.

CHAPTER VIII.

Topography of Bone and Joint Tuberculosis.

It is a well-known clinical and experimental fact that certain bones and joints are predisposed to tubercular infection.

The new vessels in the vicinity of the centres of growth in the bones of young persons, on account of their imperfect structure and irregular contour, furnish the most favorable conditions for the mechanical arrest of floating granular matter and the localization of pathogenic microbes. This predisposing anatomical element goes far to explain the frequency with which we meet with tubercular foci in the epiphysial extremities of the long bones. The following table, prepared by Schmalfuss ("Beiträge zur Statistik der chirurgischen Tuberculose." *Archiv f. klin. Chirurgie*, B. xxxv, S. 167) gives a good idea of the relative frequency with which different bones are affected with tubercular lesions:—

Billroth.	Jaffé.	Per cent.	Schmalfuss.	Per cent.
Vertebra	Vertebra	26	Knee	23
Knee	Foot	21	Foot	19
Cranium and face	Hip	13	Hip	16
Hip	Knee	10	Elbow	9
Sternum and ribs	Hand	9	Hand	8
Foot	Elbow	4	Vertebra	7.5
Elbow	Pelvis	3	Tibia	4
Pelvis	Cranium	3	Cranium	4
			Pelvis	3.6
Tibia, fibula, and femur	Sternum, clavicle, ribs	3	Sternum, etc.	3.6
Shoulder	Shoulder	2	Femur	1.9
	Femur	1	Shoulder	1.5
Humerus	Tibia	1	Ulna	1.4
Ulna	Fibula	1	Humerus	1
Radius	Humerus	1	Radius	0.7
Scapula	Scapula	0.6	Fibula	0.5
	Ulna	0.6	Patella	0.1

It is safe to state that before puberty the primary lesion in tubercular affections of joints is most frequently located in one or both of the epiphyses of the bones which enter into the

formation of the joint, while in the adult primary tuberculosis of the synovial membrane is of more frequent occurrence. As age advances and the process of ossification is completed, the predisposing localizing causes in bone apparently disappear, while the synovial membrane becomes more susceptible to primary localization. Of 204 specimens of tubercular joints, obtained from patients of all ages, examined by Mueller, 158 were primary osteal and 46 primary synovial tuberculosis. The predominance of the osseous form in these figures is owing to the large contingent furnished by patients under the age of puberty.

Jaffé's ("Ueber Knochentuberculose." *Deutsche Zeitschrift f. Chirurgie*, B. xviii, S. 432) statistic is based on 317 cases that were observed in Schede's clinic. A much larger number of cases, comprising the statistics of Jaffé, Schmalfuss, Billroth, and Menzel, is given by Cheyne (*British Medical Journal*, April 25, 1891, p. 898), who added to these 602 other cases. He gives the following topographical distribution of tubercular affections of bones and joints:—

Bone or Joint Affected.	Per cent.
Spine,	23.2
Knee-joint,	16.5
Hip-joint,	14.6
Tarsus and ankle,	14.4
Elbow-joint,	6.3
Wrist and hand,	6.0
Skull and face,	5.5
Sternum, clavicle, and ribs,	5.2
Pelvis,	3.5
Femur, tibia, and fibula,	3.5
Shoulder,	1.5
Scapula, ulna, and radius,	1.0
Humerus,	0.8
Patella,	0.1

According to this table the vertebræ are the most frequent seat of tuberculosis of all bones. Of the large joints, according to the same author, the order of frequency is as follows: Knee-joint, 16.5; hip-joint, 14.6; tarsus and ankle, 14.4; elbow-

joint, 6.3; wrist and hand, 6; and shoulder-joint, 1.5. A vast amount of material illustrative of the number of cases of joint affections requiring resection, and showing the relative number of the large joints involved, is furnished by Culbertson. This author, in an encyclopædic work on the subject of resection, gives 3908 cases of excision of the larger joints. Of this number, 596 cases belonged to the hip-joint, 745 to the knee, 326 to the ankle, 984 to the shoulder, 1079 to the elbow, and 182 to the wrist. As this table includes resections for gunshot wounds, compound fractures and dislocations, and other forms of traumatism, it does not furnish any accurate information concerning the relative number of operations done on different joints for tubercular affections.

The two infective diseases which attack the bones most frequently are acute suppurative osteomyelitis and tubercular osteomyelitis, and in reference to their location and pathological anatomy they present a series of analogies. In other respects they differ widely. Acute osteomyelitis attacks in preference the shaft of the long bones, while the tubercular form remains limited to the epiphysial extremities, as a rule, and frequently starts in the short and flat bones that are not often the seat of primary acute osteomyelitis. Lesions occur in acute osteomyelitis which are common to the tubercular variety, and both forms are equally prone to cause secondary joint diseases. The apophyses are more frequently affected by acute osteomyelitis than the shaft by tubercular osteomyelitis, with the exception of the cases of multiple miliary tubercles in the medulla of the long bones, which is found occasionally in the bodies of persons who have died of general miliary tuberculosis. Extensive tubercular disease of the marrow and shaft of the long bones is so exceedingly rare that the post-mortem room and operations on bones and joints will furnish hundreds of cases of limited tuberculosis of bone to one in which the shaft is extensively infiltrated. The favorite anatomical locations for tubercular affections of bone are in the epiphysial regions of the long

bones and in the spongy bones, and only in exceptional cases are the shaft and central medullary tissue involved. To this rule the phalanges of the hands and feet furnish an exception, as in these bones a diffuse central tubercular osteomyelitis, known as *spina ventosa*, is quite a common affection.

CHAPTER IX.

Bone Tuberculosis.

Pathology and Morbid Anatomy.—Some of the ancient authors were well aware of the frequency with which primary bone affections precede the development of joint disease. Mr. Lloyd ("On the Nature and Treatment of Scrofula," p. 120) says: "It often happens that the whole of the cancelli are nearly filled with this cheesy matter, or that several of the cellular partitions being broken down, a large mass of it is collected at one spot, while the rest of the cancelli remain entire, and are partly filled with the yellow fluid; while many of them may appear altogether empty, not even containing any of their natural secretion. Sometimes we find that only a part of the cancellous structure of the head of the bone has undergone this change. Indeed, I am inclined to believe that it often begins in the centre, as I have found the deposition of the new matter is very frequently greater there, and the exterior of the bone remains hard, as has been observed by Wiseman; while the interior is completely deprived of its earth, and so soft as to be readily cut with the knife." Albers ("Preisfrage worin besteht eigentlich das Uebel, das unter dem Sogenannten freywilligen Hinken der Kinder bekannt ist?" Beantworted von J. A. Albers, Wien, 1807) expresses his convictions on this point as follows: "I was a long time uncertain whether really the bones, as Ford asserts, were the parts first affected in this complaint (hip disease). But, partly through the excellent work of Doerner, and partly through the opportunity of opening a body in the first stage of the disease, I felt myself compelled to adopt that opinion. I found, for instance, an extensive destruction of the edge of the acetabulum, while the other parts of the hip-joint, viz., the cartilages, with the exception of a yellow spot, had suffered little or nothing."

Rust ("Arthrokakologie oder Ueber die Verrenkungen,

durch innere Bedingungen," etc., Wien) says: "I believe that this disease has its origin in a morbid state of the head of the femur, and that the diseased appearances in the other parts of the joint are to be considered as the effect of the previously existing mischief of the head of the bone."

Benjamin Brodie is also of the opinion that in strumous constitutions the disease commences in the cancellated structure of the bone, and that the affection of the cartilages and synovial membrane is secondary in the order of attack. Even among the comparatively modern writers tuberculosis of bone was considered a rare affection, and most of the chronic inflammatory conditions were regarded as one of the many manifestations of scrofula or struma.

Ried, in his classical work ("Die Resectionen der Knochen," etc., 1847, p. 79), makes a sharp distinction between scrofulous and tubercular caries, and informs us that, of the many cases of bone disease that came under his observation, he saw only four cases in which he found tubercles. He places great stress on the importance of making a distinction between the two varieties of caries which he described, as in the tubercular form he believes resection is not a justifiable procedure. Stanley ("A Treatise on Diseases of the Bones." London, 1849) speaks of a scrofulous inflammation as preceding tuberculosis, and states that a favorable prognosis should only be given before the tubercular stage has arrived, as after that time the affected bone necessarily undergoes destructive changes. He had noticed the existence of masses of chalk-like substance in the cancellous texture of bone; but did not interpret this morbid appearance in the way that Rokitansky has, by regarding the cretaceous mass as the result of the metamorphosis of tubercle in bone, analogous to the change it undergoes in other organs and tissues. Only a few cases had come under his observation in which he could satisfy himself as to the co-existence of tubercular affections of bone and pulmonary phthisis.

Even as late as 1859, Mr. Bryant ("On the Diseases and

Injuries of the Joints," p. 72. London, 1859) wished to exclude as strumous or tubercular all lesions in bone in which the inflammatory product did not consist of caseous material, as appears from the following: "I cannot for one moment doubt that the majority of the cases which are described by surgeons as strumous or scrofulous disease of a joint, and of the articular extremities of the bones, depend upon a chronic inflammation in the bone. The disease is, in its origin and progress, inflammatory, and by early treatment may be arrested. The pathological conditions found upon examination are those which an inflammatory cause will produce, and it is quite exceptional to find in any bone that yellow, cheesy material which pathologists so well know as strumous deposit. I do not deny that such a deposit may be occasionally present, but the cases in which it is found are so rare that we may fairly regard such a specimen as a pathological curiosity. If, then, we confine the term "strumous disease of bone," as I believe we should, to such instances only where such a deposit is present, as surgeons, we shall seldom have occasion to employ it."

Köster's ("Ueber locale Tuberculose." *Centralblatt f. d. Med. Wissenschaften*, No. 58, 1873) researches shed a flood of light on the pathology and morbid anatomy of chronic inflammatory affections of bone. He showed that miliary tubercles could not only be constantly found in the fungous granulations in diseased joints, but that they could be seen with equal regularity in the granulation masses in bone, tendon-sheaths, and bursæ, and later he added caseous ostitis, osteomyelitis, and caries.

In this country, H. H. Smith (*Transactions of the American Medical Association*, 1879) was one of the first to call attention to the fact that most cases of chronic osteomyelitis are of a tubercular nature. He pointed out the influence of congestion of the medulla on cell-proliferation and on the increased number of leucocytes, also the defective elaboration of blood as a result of perverted myeloid collection, and arrived at the con-

clusion that struma and tubercle are so closely allied that their differences cannot well be demonstrated.

Tuberculosis of Bone a Specific Form of Chronic Osteomyelitis.—The tubercle bacillus has a special predilection for the medullary tissue of the bones, and especially for the red medullary tissue in the cancellated tissue in the region of the epiphysial cartilage of the long bones and some of the short bones, notably the vertebræ and the carpal and tarsal bones. As an inflammatory affection it is more correct to speak of *tubercular osteomyelitis than ostitis, since the medullary tissue and the blood-vessels which it contains are the parts that take an active share in the inflammatory process.* In his experiments on animals, made for the purpose of studying the initial pathological changes in bone the seat of an active inflammation, F. Busch ("Ueber die Veränderungen des Marks der langen Röhrenknochen bei experimentell erregter Entzündung eines derselben." *Berl. klin. Wochenschrift*, No. 13, 1874) found, as the first histological changes, the medulla hyperæmic and an accumulation of lymphoid cells. In the red marrow he found, under the microscope, an aggregation of round, colorless cells, containing a large nucleus, but no nucleated red blood-corpuscles. These cells were evidently embryonal medullary cells, —the product of tissue-proliferation from the fixed myeloid cells. *The bone-cells take an active part in tubercular inflammation of bone, and it is therefore not proper to speak of the affection as an ostitis. The anatomical conditions of the vessels in the epiphysial region of the long bones in young persons, and in the vessels of the medullary tissue, favor implantation of floating tubercle bacilli upon the inner surface of the vessel-wall, and they also explain the frequency with which localization of the tubercular process takes place in this locality.* The shaft of the long bones is peculiarly exempt from tubercular disease, with the exception of the phalanges of the fingers and toes and the metacarpal and metatarsal bones in children, where the tubercular osteomyelitis gives rise to the well-known *spina ventosa* of the old authors.

Pathological Varieties of Tubercular Osteomyelitis.—The same cause—the bacillus of tuberculosis—produces different forms of tubercular osteomyelitis according to the method of infection, the number of foci, the anatomical location, the extent of the inflammation, and the stage of the disease.

Miliary Tuberculosis.—This form of tubercular osteomyelitis is not of much interest to the surgeon, as it seldom occurs as an independent affection, being usually associated with general tuberculosis. Circumscribed miliary tuberculosis often occurs in the periphery of older foci, and this is more especially the case if the primary product has undergone caseation, and the tissues around the cheesy mass are not protected by an impermeable wall of granulation tissue. The miliary nodules in bone, when found as a part of general miliary tuberculosis, present the same typical structure as in other organs. The nodules are arranged in groups in certain parts of the bone predisposed to tuberculosis, or they may be disseminated throughout the entire bone. Lazarus has recorded five cases of acute general tuberculosis in which the bones were examined with positive results. Miliary tubercles have been found in the sternum and ribs in post-mortem examinations of cases of pulmonary phthisis in the absence of general tuberculosis.

Fungous Osteomyelitis.—If the tubercular inflammation from the beginning involve only a limited area of bone-tissue, the specific product is granulation tissue. This form has been described by König as *granulating focus.* The process is an exceedingly slow one, and necrosis of the cancellated bone is either wanting or the particles of necrosed bone are so small that it often requires the aid of a microscope to detect them. The granulating focus is found as single or multiple, round or oval spaces, from the size of a millet-seed to that of a pea or hazel-nut, filled with granulation tissue, in which are often found imbedded minute spiculæ of bone. Histologically, the granulation tissue is composed of the same cell-elements as recent tubercle in other organs, only that, as a rule, the giant-

cells are more numerous and of larger size. *Direct infection of bone is an extremely uncommon occurrence; consequently, bone tuberculosis must be regarded clinically as a secondary lesion caused by an embolic infection from an older tubercular focus in some other organ.* As soon as embolic infection in bone has taken place, a process of osteoporosis and decalcification occurs around the tubercular embolus or thrombus, and the

FIG. 15.—TYPICAL GRANULATION TUBERCULOSIS OF BONE WITH MANY ROUND AND OBLONG TUBERCLES AND WITH STRIPES OF TUBERCULAR TISSUE,—TUBERCLE TISSUE. (*König.*)

pre-existing medullary and connective tissues are transformed into embryonic or granulation cells, which impart to the product of the specific inflammation its characteristic appearance. According to Kiener and Poulet ("De l'osteoperiostite tuberculeaux chronique ou carie des os." *Archiv de Phys. normal et path.*, 3 séries, tome i, p. 224), rarefaction of the bone around a tubercular focus takes place in two different ways,—either in the usual manner, by the formation of Howship's lacunæ, or by

liquefaction and disappearance of the cement-substance,—after the bone has previously presented a vitreous appearance. It is not often that only a single focus of tubercular infection in bone is present; more frequently two or three foci appear in the same region simultaneously, or in slow or rapid succession, and it is not unusual to find that two neighboring epiphyses are infected at the same time or during the course of the disease. Under favorable circumstances the granulations remain for an indefinite period of time without undergoing caseation. As long as decalcification of the surrounding bone goes on the infection is progressive, but as soon as the zone of granulation tissue around the infected focus is transformed into bone, osteosclerosis takes place, and the tubercular process, for the time being at least, becomes arrested; the micro-organisms are shut in, as it were, by an impermeable wall of sclerosed bone. *The granulating focus without caseation is the most favorable form of tubercular osteomyelitis, often resulting in a spontaneous cure, and most amenable to successful surgical treatment.* During this stage general tuberculosis is not likely to occur, as the living cells hold the bacilli in captivity, as it were, thus preventing local and general dissemination.

Caseous Foci in Bone.—A caseous focus in bone only indicates the site of a former fungous osteomyelitis, and we often meet with these two conditions side by side,—a zone of tubercular osteomyelitis around a cheesy centre.

Cheesy tubercular cavities in bone resemble the same condition in the lungs, only that secondary infection with pus-microbes is of less frequent occurrence, and on this account the cavity never attains such large size as in the latter organ. If the cavity is larger than a hazel-nut it usually contains a sequestrum of considerable size. If such a cavity is exposed in a fresh specimen by a transverse section through the bone its interior presents appearances according to the stage the tubercular process has reached. If caseation has not advanced far it contains grayish-red granulations, or the granulations present a

yellowish-gray color if caseation is well marked, or the cavity is filled with a cheesy mass when this degenerative process has been completed. If the contents of such a cavity are rubbed between the fingers minute particles of bone can usually be detected in this manner. If these particles are too small to be recognized by the sense of touch or sight their presence can almost always be demonstrated by microscopical examination. In other cases larger sequestra are imbedded in the cheesy material, and in some a large sequestrum occupies almost the entire cavity, being separated from the walls by a thin layer of granulation tissue. The color of the dead bone, owing to the presence of cheesy material in its meshes, corresponds with that of the surrounding soft mass. If the wall of the cavity is soft it usually, although not always, denotes that the disease is in an active state. As soon as the inflammatory process has subsided the osteoporotic bone becomes sclerosed, and the tubercular material is walled in and, for the time being, is rendered quite harmless. If, in the former instance, the contents of the cavity are removed with a sharp spoon, the inner portion of the wall comes away with the infected tissue, the line of demarcation between healthy and diseased tissue not being very well defined; while in the latter cases the infected material can be thoroughly removed by the same procedure without removing a portion of the wall of the cavity. In the latter instance the sclerosis of the wall of the

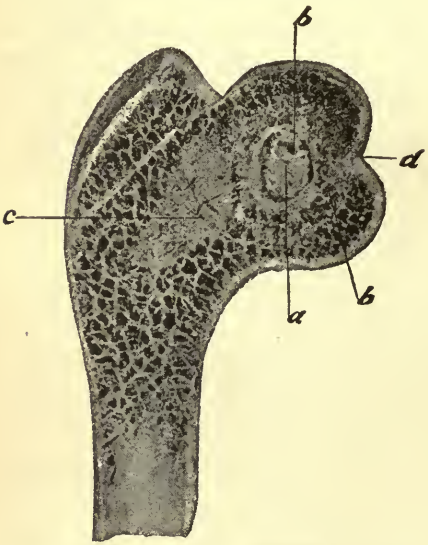

FIG. 16.—UPPER PORTION OF FEMUR OF BOY SIX YEARS OLD WHO DIED OF GENERAL TUBERCULOSIS. Natural Size. (*Krause.*)

a, cheesy focus in head of femur; *b b*, infiltration of cancellated tissue, extending from focus to shaft of femur; *d*, defect of head of femur, caused by pressure against acetabulum, which resulted in subluxation.

cavity indicates that the healing process has been completed, or at least is progressing favorably. The wall of the cavity is usually lined with granulation tissue containing the characteristic histological elements of tubercle, and if the wall is osteoporotic it usually is also infiltrated with tubercle. (Fig. 16, *b b.*) The more advanced the retrograde changes, the less marked the histological structure of the inflammatory product. In case caseation has far advanced the microscope shows only granular *detritus*, and the contents of the cavity are no longer connected with the inner surface of the wall. Cheesy foci are frequently found in the epiphysial extremities of the long bones entering into the formation of a tubercular joint. The number of such foci varies from one to seldom more than three in one articular extremity. They are also frequently met with in the bodies of the vertebræ. As in other localities, caseation in osseous foci always commences in the centre and extends toward the periphery. Numerous caseous centres in different portions of the infected area become confluent and form large masses. Near the deposit in some specimens it can be seen that the trabeculæ are thickened, and some of the cancellous spaces have lost their fat-cells and are occupied by a semi-fibrous material resembling the pathological product in some forms of synovial tuberculosis. In this form of bone tuberculosis plastic periostitis in the vicinity of the foci is not well marked. The granulation tissue, which is the characteristic product of the tubercular inflammation, absorbs the bone with which it comes in contact, and thus makes room for the inflammatory product. The gradual substitution of granulation tissue for bone explains the absence of intra-osseous tension, which is one of the prominent conditions in acute suppurative osteomyelitis. As the tubercles infiltrate the surrounding bone-tissue the lacunar absorption covers a larger field, while caseation extends from the centre of the infected area from different points. In some cases the tubercular process is more rapid, and time is not afforded for total absorption of the trabeculæ by the granulations before caseation is complete; hence, we find in

such specimens minute particles of necrosed bone. Sequestra imbedded in cheesy material remain unchanged in size, as their diminution in size or complete removal by absorption can only take place as long as they are in contact with and are acted upon by living granulation tissue.

The pathologico-anatomical diagnosis of these osseous foci is rendered more difficult by the occurrence of small foci in the apophyses which are occasionally found in acute osteomyelitis. For the expert, however, the macroscopical evidences are sufficient upon which to base a differential diagnosis. The resemblance consists only in the form and location of the foci, while the contents present characteristic peculiarities in both forms. In acute osteomyelitis the foci contain flabby granulations and pus; usually, also, small sequestra of a yellow color. If the pus in old cases become inspissated, it may present some resemblance to tubercular material, but is of an entirely different appearance. The pus is of the color and consistence of cream; or, if inspissation has advanced further, it bears a strong resemblance to moist, unslacked lime. In the granulations no tubercles can be found. If the disease, spontaneously or by appropriate treatment, come to a stand-still before it has implicated an adjacent joint or resulted in the formation of a tubercular abscess, the granulations, if they have not undergone caseation, may become transformed into connective tissue or bone, and the patient recovers not only the function of the part affected, but is protected against local and general infection from this source. If caseation has occurred, a spontaneous cure under such circumstances is still possible by encapsulation, calcification, and the formation of a wall of dense bone around the area of infection. Nélaton has given an excellent description of encapsulation of tubercular foci in bone. If the disease show no tendency to limitation, the tubercular product undergoes the typical pathological changes,—coagulation necrosis, caseation, and liquefaction of the cheesy material. If it travel in the direction of a joint, it involves the latter as soon as per-

foration takes place. *The escape of tubercular material into a joint is followed, as a rule, by diffuse tubercular arthritis, the bone affection giving rise to an inflammation of the joint identical in character with the primary bone-lesion*, the primary disease and the complication being known as *tubercular osteo-arthritis.* If the joint escape and the disease extends toward the periphery, it finally reaches the periosteum, causing a tuber-

FIG. 17. — LOWER ARTICULAR EXTREMITY OF FEMUR WITH CHEESY FOCUS, WHICH AT *a* HAS REACHED THE SURFACE OUTSIDE THE INSERTION OF THE SYNOVIAL MEMBRANE. JOINT NOT AFFECTED. (*König.*)

cular periostitis, and finally appears on the surface as a tubercular abscess. *Perforation of the periosteum often takes place close to the insertion of the capsular ligament of the adjacent joint; the joint escapes by the interposition of only a few lines of healthy tissue between it and the infected route along which the inflammatory product travels toward the surface.*

Although the joint may at first escape infection by the tubercular abscess traveling in this direction, it often becomes

involved later by the disease attacking the capsule, and finally the synovial membrane. The extension of the bone disease to the joint by this indirect, circuitous route is a very rare occurrence, as compared with direct infection by perforation of an osseous focus into adjacent joint.

Tubercular Necrosis.—By tubercular necrosis is not meant that form of bone tuberculosis in which death of minute particles of bone occurs as one of the consequences of tubercular osteomyelitis, but in which necrosis of a fragment of bone of considerable size takes place as one of the early effects of the tubercular inflammation. Tubercular necrosis, especially in its most characteristic forms, is an entirely different condition from tubercular granulating foci. It also differs materially from acute necrosis, which is caused by suppurative osteomyelitis, as the sequestrum remains for a longer time in connection with the surrounding tissues. It also differs from it in regard to the location of the sequestrum, as in the acute form the shaft is usually affected, while the tubercular variety is found almost exclusively in the epiphyses of the long bones and the short and flat bones. The sequestrum is also, as a rule, smaller, and consists of cancellated bone-tissue. The common articular sequestrum is seldom larger than a pigeon's egg. It is occasionally derived from the surface of a bone; but more frequently it is in the interior of the bone, and very often in the epiphyses of the long bones. It is wedge-shaped, the base of the wedge being directed toward the articular surface, and the apex toward the medullary cavity.

Tubercular necrosis necessarily follows if the infected area, from the beginning, exceed the size of a hazel-nut. The non-vascularity of the tubercular product and the blocking and destruction of blood-vessels, during the early stages of the inflammation, determine early death of the bone, corresponding in extent to the limits of the inflammation, and if this exceed the resorption capacity of the granulations the dead tissue is not removed by absorption, and is found as a sequestrum as

soon as it has become detached from the surrounding healthy bone. The density of the dead bone is very variable, in some less than that of normal bone; in others it resembles compact bone. If the tubercular process has been rapid, and the granulation tissue is scanty, the necrosed bone is not osteoporotic; but if the disease has pursued a more chronic course, and has resulted in the production of an abundance of granulation tissue, it presents a honey-combed appearance, is irregular in

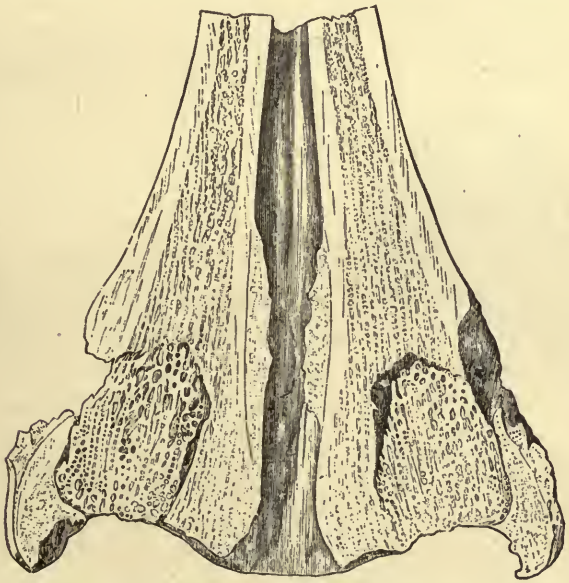

FIG. 18.—WEDGE-SHAPED TUBERCULAR SEQUESTRUM IN THE HEAD OF THE TIBIA. BONE AND SEQUESTRUM DIVIDED LONGITUDINALLY. BASE OF SEQUESTRUM EXTENDING INTO JOINT. (*König.*)

shape and variable in size, and does not correspond with the area of the infected district, as part of it has been absorbed by the granulations. In shape the tubercular sequestra are irregular, quadrilateral, or wedge-shaped, according to the structure of bone involved, the method of infection, the length of time which has elapsed, and the nature of its immediate surroundings. The cancellous spaces are filled with the products of tubercular inflammation in different stages of degeneration. The color of

the necrosed bone depends on the condition of the granulations which surround it; if these have not undergone secondary degenerative changes it may resemble healthy bone, but if caseation has taken place it is infiltrated with the cheesy material, and then presents a grayish-yellow or yellow appearance. If the dead bone has undergone no reduction in size, and the granulations surrounding it are few, it remains firmly wedged in position, and under such circumstances it is often difficult to locate the exact boundary-line between it and the surrounding healthy bone or dislodge it from its incarcerated position. König has described a form of necrosis of the articular extremities of the long bones, as a distinct variety, under the name of tubercular infarct. According to König, such an infarct, like infarcts in other tissues and organs, is always caused by impaction of an embolus in one of the distal arterial branches, and presents the same wedge-shaped appearance and peripheral zone of congestion.

FIG. 19.—RESECTED UPPER END OF FEMUR FROM A GIRL FIVE YEARS OLD. Natural size. (*Krause.*)

Large, wedge-shaped, subchondral sequestrum in head of femur, partially detached by tubercular granulations, articular cartilage elevated from base of sequestrum.

In some cases the articular cartilage is destroyed and the base of the sequestrum projects into the joint, and if the joint has still been used the surface of the bone presents a polished surface. Cheyne does not agree with König in the etiology of this form of bone tuberculosis, because, as he maintains, the dead bone shows invariably evidences of an antecedent inflammation. He asserts that certain areas of bone-tissue are destroyed by the tubercular inflammation, and that sequestration always takes place by the absorption of trabeculæ in the periphery of the necrosed bone. That a fragment of tubercular tissue impacted in a small artery may be the cause of a tubercular necrosis has been shown experimentally by Müller. That tubercular necrosis, like other forms of bone tuberculosis, is

usually associated with antecedent tubercular foci is well known. If a minute fragment of tubercular tissue should reach the general circulation, localization would most frequently occur in the tissues and vessels predisposed to such an occurrence, and this is notably the case in the medullary tissue and blood-vessels in the epiphysial region of the long bones in children and young adults. The size of the vessel obstructed by an infected embolus will determine the extent of the necrosis. If the embolus is small, the area of necrosis may be increased by the blocked vessel becoming the seat of secondary thrombosis, obliteration of the vessel taking place in a proximal direction by growth of the thrombus toward the heart. The common articular sequestrum is seldom larger than a pigeon's egg. As the cortical portion of bone is seldom involved by a tubercular infarct, the necrosed area is often overlooked in operations on tubercular joints unless the bone is sawn through. In the living bone it is sometimes very difficult to demonstrate the presence and contour of the sequestrum, so small are the differences between the dead and living bone; we often have to rely on the color alone to determine the presence and outlines of the sequestrum. The dead bone appears of a dirty-white or yellowish-white color, while the surrounding bone presents a normal pinkish hue. If the dead bone is scraped, cheesy material is obtained. The difficulty in recognizing the dead bone is often enhanced by the density of the sequestrum, which often equals that of the surrounding healthy bone. In other cases the sequestrum appears sclerosed, harder than the surrounding bone,—a condition which can only be explained by the fact that soon after the commencement of the disease the bone around the sequestrum becomes rarefied, so that the sequestrum represents the normal density of bone, while the surrounding bone has become osteoporotic. At other times the impression is received that sclerosis of the sequestrum is an initial condition of the tubercular process.

An anatomical diagnosis is often a matter of great difficulty,

as no line of demarcation can be seen separating the living from the dead bone. Separation of the sequestrum takes place more slowly than after suppurative osteomyelitis, the process requiring often, according to the size of the sequestrum and the activity of the inflammatory process, months and years for its completion. If the granulations which surround the sequestrum do not undergo cheesy degeneration the bone becomes imbedded and fits accurately into the cavity, and if the surrounding zone of granulation is converted into connective tissue it may become permanently encapsulated; but even from such an apparently healed depot local and general infection can occur at any time. Intermediary forms of bone tuberculosis occur between the granulating foci and tubercular necrosis just described.

In such foci the granulations become gradually more and more abundant at the expense of the sequestrum or the surrounding osteoporotic bone, and finally the detached necrosed bone lies in the cavity, loosely imbedded in the granulations. In the necrotic form of osseous tuberculosis we observe, as a rule, more frequently hyperplastic tissue-proliferation around the seat of inflammation after the formation of fistulæ than in the granulating focus. The microscopical examination in this variety of bone tuberculosis presents greater difficulties in demonstrating the presence of tubercle bacilli than is the case in fungous osteomyelitis; yet, as a rule, they can be found in the sequestrum and granulations. In conducting this method of examination it is necessary that the bone should be decalcified and sections of it stained and examined under the microscope. In specimens thus prepared it can be seen that the blood-vessels still exist in some of the Haversian canals to a certain depth; those of the Haversian canals are filled with cells and granular *detritus*. Scanty remnants of epithelioid and giant cells can also be found. Such sequestra may remain in the place where they originated years after apparent healing has taken place, and are then connected with the surrounding bone by connective tissue. König is of the opinion that the tubercular infarct in

bone is caused by a tubercular embolus derived from some distant antecedent tubercular focus, and that this plug contains the essential cause of the tubercular process,—the bacilli of tuberculosis. He claims that necrosis would not take place if, from such an embolus, bacilli would not reach the terminal arterial vessels, causing complete obstruction in these vessels on the distal side of the primary obstruction. The extension of the disease is due to spreading of the tubercular inflammation along the course of the small vessels. The fate of the affected bone and the surrounding tissue is variable. Under the most favorable conditions a tubercular focus heals completely. Such a favorable termination can be expected most frequently in the granulating form of osseous tuberculosis. After the tubercular granulations have undergone retrograde metamorphosis their place is taken by vigorous granulation tissue, which spring from the adjacent healthy tissue, and these are transformed into connective tissue, which, by growing into and around the tubercular material, gradually takes its place. Spontaneous cure is often more apparent than real, as some of the tubercular granulations remain, and in such a partially healed focus a new tubercular inflammation may be lighted up at any time under the influence of adequate local or general conditions. Such recidivations are often observed in tubercular affections of the hip- and knee- joints after the original partially healed affection has remained in a latent condition for years. Small sequestra are often completely removed by granulation tissue if caseation of the tubercular product has not occurred, but not infrequently it is the case, in the event that they are too large to be completely removed in this manner, that they are rendered innocuous by becoming permanently imbedded in connective tissue, while encapsulation of a large sequestrum never occurs.

Diffuse Tubercular Osteomyelitis.—Independently of general miliary tuberculosis diffuse tubercular osteomyelitis is quite rare. It occurs more frequently as a secondary affection from a tubercular joint than as a primary osseous lesion.

Kiener and Poulet (*op. cit.*) have described a form of secondary tuberculosis of bone with rapid extension of the process. Here the disease originates in persons debilitated in consequence of a primary tuberculosis in a bone that has already undergone extensive pathological changes. This form is characterized by a tendency to suppuration and the production of fungosities in the surrounding tissues. It appears under two principal varieties: 1. Progressive tuberculosis with attached sequestrum; that is, the meshes of the sequestrum are filled with granulations growing into them from the interior surface of the cavity; this is the *caries fungosa* of the old authors. 2. Circumscribed tuberculosis with small sequestra, surrounded by suppurating granulations; by the rapid extension of the tubercular process at circumscribed points several sequestra are produced simultaneously, which excite massive fungosities in their vicinity. The same authors describe another form of bone tuberculosis which they term *acute progressive tubercular osteomyelitis*, and which, according to their observation, is characterized by a tendency to early suppuration. This form is exceedingly rare and often involves almost an entire epiphysis, the analogue of acute cheesy pneumonia. It resembles closely acute suppurative osteomyelitis, but microscopic examination shows all the characteristic appearances of tuberculosis, condensating and rarefying osteomyelitis, cheesy degeneration, and tubercle formation upon the blood-vessels, production of small sequestra and fungosities. The clinical and pathological characteristics of this local form of bone tuberculosis consist in the rapid extension of the affection and the danger to life from general infection. On making a longitudinal section through a long bone affected by diffuse tubercular osteomyelitis, we observe conditions which closely resemble acute suppurative osteomyelitis. We find large, irregular, often multiple areas of a yellowish-white infiltration, with numerous foci of liquefied cheesy material. The infection extends from the epiphyses of long bones to the medullary cavity and the periosteum, along the Haversian canals and the

blood-vessels. The secondary periostitis caused in this manner, as a rule, assumes a plastic type, resulting in the formation of diffuse, irregular masses of new bone. In these cases there is no tendency whatever to limitation in the formation of sequestra, but rather a tendency to spread indefinitely and to invade even the medullary tissue of the shaft. If the spongy bones are the seat of this process the disease extends with great rapidity, and in a short time the entire bone is diffusely infiltrated. Patients suffering from this rapid form of tubercular osteomyelitis are exposed to all the dangers incident to diffuse general miliary tuberculosis if the infected tissues are not removed by a timely and thorough operation. In operating it is important to recognize this form, since it requires more radical measures,—either amputation or very extensive excision of the entire thickness of the affected bone. Less heroic local measures, such as will meet the indications in other less diffuse varieties of osteotuberculosis, are of no avail.

Caries.—Caries of bone should no longer be spoken of as *a disease, but as one of the effects of some destructive disease of bone.* Macroscopically and microscopically caries of bone resembles an ulcer of the soft parts, and it would not be inappropriate to describe it as an ulcer of bone. Tuberculosis of the periosteum and of bone are the affections which most frequently produce caries. Every tubercular cavity in bone lined with granulations presents a carious surface as long as the primary disease remains in an active state. Every tubercular abscess in communication with a tubercular osteomyelitic focus has carious bone at its bottom. A tubercular periostitis leads to caries at an early stage by the extension of the tubercular process to the subjacent bone. Caries of the articular extremities of the long bones arises in the course of primary or secondary tuberculosis of joints as soon as the articular cartilages, in whole or in part, are destroyed by the tubercular granulations. Caries of the vertebræ, like that of other short, flat, and irregular bones so frequently referred to in the old text-books, and even in many of more

recent date, as a disease, is, in a great majority of cases, nothing more or less than tuberculosis of those bones.

Destruction of articular cartilage by primary or secondary synovial tuberculosis does not always necessarily result in caries of the articular ends, as, under favorable conditions, the destructive process is arrested before it extends to the bone, and a new covering of fibrous tissue takes the place of the articular cartilage. Carious bone is always covered more or less by granulations, and the enlarged cancellous spaces are occupied by the same material. The granulations detach small fragments of bone, which remain imbedded in the soft, flabby granulations, and afterward become part of the abscess contents, or are eliminated with the discharges through fistulous tracts. At a little distance from the tubercular granulations the bone is osteoporotic, but immediately beneath it the cancelli contain young fibrous tissue, and it is here that thickening of the trabeculæ takes place. After the cartilage has disappeared the disease extends to the surface of the bone, which soon becomes covered with granulations, in which all of the histological elements of tubercle can be found. The tubercular process extends, step by step, into the bone, new areas becoming successively involved, while the older portions undergo caseation and liquefaction. Immediately beneath the infected tissues there is usually a narrow zone of plastic osteomyelitis, while more remote from the disease there may or may not be an osteoporotic condition of the bone, often in circumscribed patches. The destructive process takes place most rapidly at points subjected to greatest pressure. Thus, in coxitis, the rim of the acetabulum or upper segment of the head of the femur suffers the most from pressure of the head of the femur, and in tuberculosis of the knee-joint the articular ends show the greatest defects at points subjected to the greatest pressure. The detachment of fragments occurs by lacunar absorption of portions of the trabeculæ. This interstitial absorption of bone is accomplished exclusively by living granulations, and can only

occur in places where these have not undergone caseation. *Surface caries, as a rule, is always superficial, never involving more of the bone than a quarter of an inch in thickness.*

Caries sicca is a form of caries which was first minutely described by Volkmann as a definite pathological variety of tubercular joint disease. *The most characteristic features of this kind of caries are absence of suppuration, obliteration of the cavity of the joint, and sclerosis and concentric atrophy of the articular extremity of the bone.* The yellow appearance of the sclerosed bone is due to fatty degeneration of the contents of the cancelli, and not to infiltration with tubercular material. Caries sicca is met with most frequently in the shoulder-joint, and is a form of joint tuberculosis which most frequently terminates in a spontaneous cure, without surgical interference.

Tubercular Periostitis.—Tubercular periostitis of the long bones is a comparatively rare affection, being far less frequent than syphilitic periostitis. This affection as a primary disease involves most frequently the vertebræ, ribs, cranium, and bones of the face. In the last locality it attacks the orbital border of the malar bone most frequently. As a secondary affection in tuberculosis of the long bones, it develops most frequently in connection with the diffuse infiltrating form of osteotuberculosis. In tuberculosis of the ribs the disease starts most frequently in the periosteum, and the bone is gradually destroyed from without inward. The compact layer of the ribs at points corresponding to the disease in the periosteum shows, at first, minute circumscribed defects, which gradually enlarge, imparting to the bone a worm-eaten appearance. The disease often destroys the continuity of the bone, giving rise to a pathological fracture. It not only spreads in the direction of the bone, but also, by continuity, along the periosteum, terminating frequently only with the destruction of the entire periosteal envelope. The periosteum being the primary starting-point of the disease, extension of the process to the tissues outside of

the periosteum is an early occurrence. In the adult, tubercular spondylitis is most commonly the result of an extension of the disease from the periosteum. A number of vertebræ are attacked simultaneously, or in rapid succession, and the formation of a tubercular abscess must be expected. Curvature of the spine is frequently absent, and when present it is not as angular as when the disease attacks primarily the body of one or more of the bones. As a secondary disease in tuberculosis of the long bones it is rare, except in the diffuse variety. When the dry, granulating focus reaches the periosteum, a small, soft, elastic, limited granulation swelling forms, first under, later outside of it. It is characterized by slow growth, comparatively little pain, slight tenderness, and a tendency to remain stationary for a long time. If, however, the central focus has become cheesy, and the liquefied, cheesy material comes in contact with the periosteum and paraperiosteal tissues, a tubercular abscess forms in a short time. As soon as the periosteum has been perforated the cheesy material infects the connective tissue, which then takes an active part in the formation of the tubercular abscess; the periosteum ruptures spontaneously, the skin overlying it becomes tubercular and presents subsequently, at the point of perforation, the appearance of lupus. In the differential diagnosis between a tubercular and syphilitic periostitis, the character of the swelling is of great importance. In the former, central softening is of frequent occurrence, and takes place earlier than in the latter; at the same time, pain and tenderness are not as well marked as in syphilitic gumma of the periosteum.

CHAPTER X.

Etiology of Bone Tuberculosis.

Tuberculosis of bone occurs either as a primary or secondary affection. In the former instance we understand that localization of the bacillus of tuberculosis has not taken place in any other organ of the body, and that the tubercular lesion in bone presents itself as an isolated single affection. Little is known concerning the channels through which primary infection takes place. We have reason to believe that this occurs most frequently through the respiratory and digestive organs. Through these routes the bacilli of tuberculosis enter the general circulation and localize in the capillary vessels of those parts of the bones which are anatomically predisposed to localization of floating micro-organisms. The frequency with which pulmonary tuberculosis is met with in cases of bone tuberculosis, and the fact that the thoracic duct is also quite often the seat of tuberculosis, speak in favor of this assumption. We have no reliable evidence that infection rarely, if ever, takes place through a wound in a healthy person. Clinical experience tends to prove that primary tuberculosis of bones and joints is exceedingly rare, or, perhaps, does not occur at all. The tubercular lesions which give rise to metastatic tuberculosis may be very minute and elude detection, even on making a careful examination. A small cheesy deposit in the lungs, a hidden caseous lymphatic gland, may be sufficient, under certain conditions, to give rise to numerous metastatic foci. Carefully-made autopsies can only furnish additional reliable information on this subject. Buhl's assertion, that in tubercular affections of different organs without an old tubercular focus, this was not absent but overlooked, may yet receive corroboration by careful research in the future. Orth made 67 autopsies in the Göttingen clinic of patients that were the subjects of tuberculosis of bones and joints which had been subjected to operative treat-

ment. In 14 of these, caseous foci were found in other organs which could be regarded as the cause of the bone and joint affections, thus giving in only 21 per cent. caseous foci as the source for the metastatic bone and joint affections. The number of those in which the post-mortem revealed only osseous foci were the following:—

Of 30 hip-joints,	5
Of 17 knee-joints,	2
Of 8 ankle-joints,	1
Of 11 tuberculosis of vertebræ,	5
Of 1 multiple disease of bones,	1

The 67 autopsies showed 55 times, besides the bone and joint disease, older foci. Among these, the lungs were the seat 37 times; the lymphatic glands 21 times. Most frequently the bronchial glands were affected; next in order came the mesenteric and retro-peritoneal, and least frequently the glands of the neck and extremities. The genito-urinary organs were affected 9 times, as a rule complicated by pulmonary tuberculosis. Secondary tuberculosis of bones and joints is a common clinical occurrence. As has been previously stated, what is generally regarded as a local bone tuberculosis (by which we mean the absence of recognizable tubercular lesions in other organs) is, in reality, in the majority of cases, a secondary disease, resulting from the introduction of bacilli through the respiratory or alimentary tract into the circulating blood with localization in the bone, or the entrance of bacilli into the circulation from a pre-existing but undetectable tubercular product with secondary localization in bone. In this sense a primary, or, to use a more correct expression, a localized osseous or articular tuberculosis is, according to Kummer, found in about 40 per cent. of the cases; in the remaining 60 per cent. depots are found at the same time in other organs: the lung comes first, with 25 per cent.; then joints, 10 per cent.; afterward bones, 10 per cent.; lymphatic glands, 10 per cent.; peritoneum, 3 per cent.; pleura, 2 per cent.; the usual history being in such cases something as follows: A patient has passed through an

attack of pleuritis, during which he has, perhaps, expectorated blood; but after awhile apparent recovery follows, but the patient has lost a great deal of flesh and does not gain in weight; at the same time the appetite is impaired. Frequently, more or less cough remains; a slight trauma lights up an inflammation of a joint; a tubercular abscess forms, which communicates with an osseous focus. In persons advanced in years, a primary synovial tuberculosis is likely to develop under such circumstances. At other times an osseous or joint tuberculosis is preceded by a tubercular affection of the genito-urinary organs. A correct diagnosis in such cases can usually be made without much difficulty. In persons the subjects of a cheesy deposit in some organ of the body a metastatic affection of bones or joints frequently follows a slight injury.

In König's cases such a connection between an old tubercular process and a trauma causing bone tuberculosis was always established. Even in persons apparently in good health the subsequent history revealed the existence of a tubercular affection of long standing, and he relates a number of interesting cases which substantiate this statement. After a trauma, however, the tubercular lesion can originate in the same manner as in acute osteomyelitis, in which a depot in the body does not invariably exist. In such cases we must take it for granted that the bacilli which have entered the circulation through the respiratory or digestive organs have not localized until the *locus minoris resistentiæ* is created by the trauma. *The trauma only serves as an exciting cause in the production of bone tuberculosis in persons already infected with the essential cause. Clinically, tuberculosis of the bones can be traced only in a small percentage of the cases to a traumatic origin.* It is, as Volkmann asserted long ago, characteristic that the traumatism is always slight, often quite insignificant; tuberculosis of bone, even in tubercular subjects, seldom, if ever, follows a fracture, as the injury in such cases is productive of such active cell-proliferation that it will hold in abeyance the pathogenic action of the bacilli which

might reach the seat of injury with the extravasated blood. It is also possible that, in many cases at least, the attention of the patient or his friends is first accidentally called to an existing tubercular focus by the immediate effects of the injury, the latter having had no influence in the causation of the disease. Every child large enough to run around injures himself more or less almost daily, and yet tuberculosis of bones and joints follows as a consequence only in comparatively few; and in such cases the essential cause must be present in the blood or tissues at the time the injury is received. To show the influence of trauma in exciting tubercular disease of bone, Cheyne (*British Medical Journal*, April 25, 1891) made a study of 293 cases which came under Sir Joseph Lister's and his own observation during the course of several years. In 188 of these cases no definite cause was assigned, while in 105, or 38.8 per cent. of the whole, the trouble was directly ascribed to the injury. In these cases the males were considerably in excess of the females, namely, 194 : 99, or 66 per cent. : 34 per cent. Of the 194 males there was no history of injury in 113, and of the 99 females there was none in 75, or a percentage proportion of uninjured males and females of 66 : 40. This leaves 81 males and 24 females with a history of injury, or a percentage proportion of 77 : 23. The facts are more striking if we contrast the cases commencing before and after 10 years of age, in males and females respectively, as shown in the following table:—

Percentage Proportion of	*First Decade.*	*Later.*
Uninjured and injured males,	67.1 : 32.9	53.2 : 46.8
Uninjured and injured females,	68.8 : 31.2	81.5 : 18.5
Total males to total females,	60.8 : 39.2	69.6 : 30.4
Uninjured males and uninjured females,	60.2 : 39.8	60.0 : 40.0
Injured males to injured females,	62.1 : 37.9	85.3 : 14.7
Uninjured males during the two periods,		41.6 : 58 4
Uninjured females during the two periods,		40.3 : 59.7
Injured males,		28.4 : 71.6
Injured females,		58.4 : 41.6

Before 10 years of age the liability in males and females is about the same, showing that the injuries to which males are

more subjected after this time of life play an important part in the causation of tubercular affections of bone and joints, as after 60 years of age the proportion in both sexes is again about the same. The cases following an injury, as a rule, are of a graver form.

Thus, of 301 cases of tubercular disease of joints collected by Cheyne, the bone was primarily affected in 94, or 31.2 per cent.; of 193 uninjured cases, the bone was the primary seat of the disease in 41, or 37.9 per cent. Chronic inflammation is a local predisposing cause to tubercular inflammation. Suppuration aids in spreading the disease, which is best shown by the difference in the behavior of tubercular joints incised with and without antiseptic precautions. Tubercular meningitis more frequently develops in connection with septic than aseptic tubercular lesions. In reference to age as a predisposing factor, Cheyne gives the following table:—

	1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	41-45	46-50	Above 50.
Total	23.2	16.0	14.6	15.0	8.5	8.8	4.0	3.0	2.0	2.0	2.0
Males. . . .	11.3	9.5	9.5	9.5	6.3	5.3	4.0	2.4	2.0	1.8	1.0
Females . .	8.8	6.5	5.0	5.8	2.0	3.3	. .	0.8	. .	0.4	1.0

It is also interesting to note that age predisposes to the localization of the tubercular process in certain joints. Cheyne gives the following table to illustrate that part of the etiology of tuberculosis of bones and joints:—

	Hip.	Knee.	Ankle.	Tarsus.	Shoulder.	Elbow.	Wrist.	Spine.
First decade	30.2	29.5	5.4	4.6	. .	6.7	0.6	12.0
Second decade	20.3	22.8	5 9	5.9	1.6	. .	8.4	15.2
Third decade	4.8	18.2	3.6	8.4	4.8	6.0	15.8	28.0
Fourth decade	.	36.6	3.3	3.3	. .	13 3	13.3	20.0
Fifth decade	12.5	6.2	12.5	18.7	. .	18.7	6.2	12.5

Heredity is an important factor in the causation of bone tuberculosis, as well as tuberculosis of other organs. Tubercu-

losis in the newborn has never been found in this locality, but it is well known that it can appear within a few months after birth, and the conditions under which this occurs are familiar. I have repeatedly observed well-marked and typical tubercular lesions of bone and joints in infants from a few months to a year of age, in exciting tubercular disease of bone. In 188 of the cases reported by Watson Cheyne we must take it for granted that direct transmission from parent to child is possible, but that it takes place very rarely. A hereditary predisposition to tuberculosis exists, and has for years been quite generally accepted as a well-established clinical fact. By this is meant a peculiar vulnerability of the tissues and a susceptibility to tubercular infection. In children so predisposed the clinical history often reveals obstinate eczema, blepharitis ciliaris, glandular enlargements, and other affections of undoubted tubercular nature during early childhood, preceding the bone affection. Surgeons are well aware of the fact that the existence of a hereditary tendency to tuberculosis adds greatly to the gravity of the disease. The course is usually more rapid, spontaneous cure less likely, and the prospects of a favorable result after operative treatment less favorable than in the acquired form of bone tuberculosis. Wealth furnishes no protection against this form of bone affection, as it is equally prevalent among the rich and the poor. The diseases incident to infancy and childhood, such as pertussis, rubeola, and scarlatina, frequently furnish the necessary conditions for the development of osteotuberculosis. In the adult the attack is often preceded by one of the acute infectious diseases, such as typhoid fever, pneumonia, and pleuritis. Pregnancy and lactation are also important etiological factors.

CHAPTER XI.

Symptoms and Diagnosis of Tubercular Bone Affections.

During the early stage of tubercular inflammation of bone the first local symptoms are often referred to the nearest joint, and in osteotuberculosis of the hip to the knee-joint. The general symptoms are often no indication of the existence or extent of the local disease, as patients with quite extensive bone tuberculosis may present every appearance of perfect health, and a small osseous focus may produce a rapidly fatal miliary tuberculosis. Uncomplicated tuberculosis of bone is essentially a chronic process, and the general symptoms furnish but little information in reference to its inflammatory character. Febrile reaction is slight or entirely absent. More than ten years ago, König called attention to the fact that a slight rise in the temperature is frequently present, even in limited local tuberculosis. If the thermometer shows a normal or subnormal morning temperature, and a slight rise toward evening, if not more than half a degree Fahrenheit, but continued for weeks and months, it indicates a careful search for a local tubercular focus. The local surface temperature is not sensibly increased. Progressive anæmia is always an unfavorable symptom in all forms of local tuberculosis, as it indicates either the presence of additional foci in important organs, or accompanies the exhaustive purulent discharges after secondary infection with pus-microbes.

Laker ("Die Bestimmung des Hæmoglobingehaltes im Blute mittels des von Fleischl' schen Hæmometers." *Wiener Med. Wochenschrift*, B. xxxvi, 1886) has ascertained that the blood of patients suffering from bone and joint tuberculosis is deficient in hæmoglobin. The occurrence of mixed infection, with or without a direct *infection-atrium*, is usually announced by a high temperature and other symptoms of septic infection. Emaciation is seldom a marked feature of bone tuberculosis unless a number of bones are affected simultaneously, or after

the case has resulted in the formation of tubercular abscesses which have become the seat of secondary infection with pus-microbes.

The local symptoms vary according to the location, conditions, and size of the tubercular focus and the presence or absence of complications.

Pain.—Pain is an almost constant symptom, but its intensity is subject to great variation. Unlike in acute suppurative inflammation of bone, the inflammatory product does not give rise to the same degree of tension; hence, pain is not so prominent a symptom. The primary exudation and transudation in tubercular inflammation are always scanty, and the inflammatory product is composed mostly of granulation tissue derived from pre-existing fixed tissue-cells; at the same time the surrounding bone-tissue becomes osteoporotic, and yields more readily to pressure. Consequently, tension is to a great extent avoided, and pain is slight as compared with the acute and intense suffering caused by acute osteomyelitis. Children suffering from spina ventosa complain of little or no pain, although a whole phalanx of a finger may be almost completely destroyed by a tubercular osteomyelitis. In such cases the granulation tissue is formed slowly; the compact layer of the bone is rendered osteoporotic and becomes greatly attenuated, and generally yields readily to the prolonged intra-osseous pressure and expands, perhaps, to twice its normal circumference. Pain is slight, or entirely absent, because no great intra-osseous tension has occurred. That tension or pressure greatly aggravates pain in osseous tuberculosis is one of the most familiar facts in surgery. This symptom is promptly relieved in a case of tubercular spondylitis by suspension and fixation and rest in the recumbent position, and greatly aggravated by flexion of the spinal column, which necessarily produces pressure upon the bodies of the inflamed vertebræ. In osteo-arthritis of the large joints pain is relieved by rest and extension, and is always increased by use of the limb or by pressing the inflamed articular

surfaces against each other. It may be stated, as a rule, that the intensity of the pain bears a direct relationship to the acuteness of the inflammatory process. The pain is of a dull, aching character, and is intermittent and more severe during the night. The nocturnal exacerbation of the pain, as evidenced in children by restlessness during sleep, moaning, grinding of teeth, and horrible dreams, is often one of the first symptoms which excites suspicion of the existence of osteotuberculosis. The pain is not always referred to the seat of lesion. Tubercular osteomyelitis of the head and neck of the femur gives rise to pain in the region of the knee-joint, which is intensified by movements of the hip-joint or by making pressure against the great trochanter, while manipulation of the knee-joint, if the hip is immobilized, does not increase it. Children suffering from tuberculosis of the spine usually refer all the suffering to the pit of the stomach, or to some other part of the abdomen supplied with nerves that take their exit from the spinal canal at a point corresponding to the inflamed vertebræ.

Tenderness.—The periosteum covering the bone overlying an osseous focus at a comparatively early stage of the disease becomes the seat of inflammation before it is reached by the tubercular process. This circumscribed periostitis gives rise to tenderness. *The existence of an area of tenderness over a point corresponding to a tubercular focus in the interior of a bone is one of the surest indications of the existence of osteotuberculosis.* In many cases of epiphysial tuberculosis patients have been treated for some supposed lesion in the adjacent joint, simply because this symptom was not carefully searched for, or, if discovered, its significance was misinterpreted. In such cases the existence of a limited area of tenderness in the epiphysial line and the absence of joint-lesions will enable the surgeon to locate accurately a focus in the interior of the bone. The area of tenderness to be outlined by making pressure at different points with the tip of the index-finger at least approximately corresponds with the circumference of the tubercular

focus. If more than one focus is present in the articular extremity of a long bone the number of tender points will correspond with the number of foci in the bone. Whether a central focus in a bone could be always recognized by relying upon this symptom is somewhat doubtful; but usually the foci are located sufficiently near the surface of the bone to give rise to secondary limited periostitis and points of tenderness, which can be readily located by finger pressure. In the examination of tubercular joints it is important to search for this symptom over both articular extremities, for the purpose of detecting osseous foci,—a matter of great importance not only from a diagnostic, but also from a therapeutic, stand-point.

Swelling.—The opinion prevailed among surgeons for a long time that the swelling in tumor albus was caused by enlargement of the articular extremities of the bones. Mr. Lawrence, of St. Bartholomew's Hospital, first called the attention of Mr. Crowther ("Crowther on White Swelling." London, 1808) to the fact that in the specimens of white swellings in the museum in that institution the diseased bones did not show any enlargement. Until that time it had always been taught that in this disease the bones underwent enlargement; but the specimens examined for this special purpose demonstrated the incorrectness of this assertion. Samuel Cooper ("First Lines of the Practice of Surgery, and a Concise Book of Reference to Practitioners"), somewhat later, made the following statement concerning this question: "I have been in the habit of frequently inspecting the state of the numerous diseased joints which are annually amputated in St. Bartholomew's Hospital; and, though I have long been attentive to this point, my searches after a really enlarged scrofulous bone have always been in vain." Mr. Crowther very properly remarks that an exception should be made in the case of spina ventosa, an affection in every way analogous to strumous disease of the articular ends of the long bones, and in which the spindle-shaped enlargement of the bone is the most characteristic fea-

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ture of the disease. I have also seen a number of cases of diffuse tubercular osteomyelitis of the long bones in which the shaft was much enlarged, its surface irregular, the bone itself softened, and presenting numerous defects. The diffuse form of tubercular osteomyelitis is always attended by a plastic osteomyelitis, and, consequently, the early appearance of external swelling is one of the points to be taken into consideration in differentiating between the different forms of osteotuberculosis. With these exceptions the bone itself is generally not much enlarged by tubercular inflammation. External swelling is absent until the atrophic layer of compact bone yields to the intra-osseous pressure,—as may be seen in advanced cases of spina ventosa,—or until, by pressure-atrophy over the centre of the focus, the compact layer is perforated, and a soft, circumscribed, boggy swelling forms underneath the periosteum. If the granulation tissue has retained its vitality the extra-osseous swelling increases very slowly in size, and there is no tendency to diffuse infection of the connective tissue after the tubercular product has reached the paraperiosteal tissues. Pseudo-fluctuation is generally present, and many such granulating foci at this stage have been carelessly incised under the mistaken diagnosis of abscess. If the central focus has undergone caseation before the periosteum is perforated, then the paraperiosteal tissues become rapidly infected, and a tubercular abscess, such as has been described above, develops in a short time. The abscess wanders away from the place where it originated in directions offering the least resistance, along preformed anatomical spaces, and in obedience to the law of gravitation. The size of such an abscess is, absolutely, no indication of the extent of the primary lesion in the bone, as a minute focus may be the cause of a large abscess, and a small abscess may mark the location of an extensive primary bone-lesion. Œdema is usually not well marked, even if the abscess is large, unless secondary infection with pyogenic microbes has occurred. The swelling that attends tuberculosis in bones deeply seated—as

the vertebræ, head and neck of femur, and pelvic bones—does not become apparent until the existence of a tubercular abscess indicates the probable seat of the primary lesion.

Redness.—The skin over a tubercular focus, in the interior of a bone or over a tubercular abscess, presents a normal appearance until it has become infected and shows other unmistakable signs of tuberculosis. Before this has occurred the skin stretched over a deep-seated tubercular product is thinner than normal, extremely pale, and usually traversed by large and conspicuous veins, and not attached to the deep tissues. More serious changes in the skin do not occur until the granulations have permeated its deeper layers, or until the caseous material has become subcutaneous. Under such circumstances the skin presents a dusky-red or livid, leaden hue, owing to impaired capillary circulation, and becomes more and more attenuated by pressure-atrophy and destructive changes, until it finally yields to the pressure from beneath, and spontaneous evacuation of the contents of the abscess takes place. If the subcutaneous product is composed of granulation tissue, the undermined skin, after perforation has taken place, is destroyed by degrees, and the parts present the appearance of lupus.

Atrophy of Limb.—Atrophy of bone and muscles is a constant symptom in osteotuberculosis as well as in tubercular synovitis. This atrophy is not caused altogether by inactivity of the limb, but appears to be due, in part at least, to trophoneurotic lesions. In an exhaustive paper on this subject, Duplay and Cazin (*Archives Générales de Médecine*, January, 1891) first review the various theories which have been advanced at different times to explain the secondary muscular atrophy in connection with tuberculosis of bone and joints, such as mechanical stretching, functional inactivity, propagation of inflammation to the muscles, and vasomotor changes, all of which appear to them insufficient. Most authors have accepted the reflex theory, advanced first by Vulpian, namely, that the irritation of the ends of the articular nerves reflect back on the spinal

centres, and from there upon the centres of origin of the muscular nerves. This accounts well for the rapid development of the atrophy, the absence of the reaction of degeneration, and the simple atrophy found in the muscles. In one case Klippel found degenerative atrophy in the muscles and changes in the corresponding anterior horn, but this is altogether exceptional. One may believe with Charcot that there are two kinds of this muscular atrophy,—one functional, with simple atrophy; the other more serious, with organic lesions in the cord and degenerative atrophy of the muscles. Duplay and Cazin studied this subject experimentally on dogs and rabbits. They produced artificially inflammation of joints by injecting nitrate of silver or tincture of iodine, or by the use of the actual cautery. The muscles weighed always showed a loss,—in one or two instances as much as 40 per cent., usually in proportion to the duration of life (four to fifty-one days). In one experiment the joint was mechanically injured, and the animal was allowed to live for a year. Histological examination showed a simple atrophy in the muscles, and the nerves were all healthy except the articular branches. Here there was a diminished number of nerve-fibres, a few of which were degenerated, the axis-cylinder having disappeared. The nerve-sheath showed inflammatory changes, but the endoneurium was unaffected. This agrees perfectly with the theory of Vulpian. The predominance of the change in the extensor muscles may be explained by the relation of the articular nerves to the nerves supplying these muscles. This cannot take place without the intervention of the spinal cord, and, indeed, a connection between the centres of the articular and muscular nerves in the cord may be assumed. Struempell ("Ueber Muskelatrophie bei Gelenk-leiden und über Atrophische Muskel-lähmung nach Ablauf des acuten Gelenkrheumatismus." *Münch. Med. Wochenschrift*, No. 13, 1888) is of the opinion that muscular atrophy, which attends inflammatory affections of joints, follows in consequence of the extension of the pathological conditions directly from the joint to the muscles.

Bock ("Contribution à l'etude de l'arthrite mono-articulaire chronique et son traitement." *Journ. de Bruxelles*, June 20, 1888) believes that in disease of the knee-joint the triceps femoris undergoes serious nutritive changes in consequence of an ascending neuritis of the nerve which supplies this muscle, and explains the immunity of the sciatic by calling attention to the intimate relation of the former nerve to the joint and periosteum, which make it possible for the inflammatory process to extend from the joint directly to the nerve, while the sciatic has no such direct anatomical connection with the joint. The same explanation is given by Garrod ("A Contribution to the Theory of the Nervous Origin of Rheumatoid Arthritis." *Med. Chir. Transactions*, vol. lxxi, p. 89) of the occurrence of muscular atrophy in cases of arthritis deformans. The following conclusions may be drawn: 1. The usual inactive atrophy of the affected limb in bone and joint tuberculosis is a simple atrophy, and in the majority of cases is increased by a simple reflex, set up by the irritation of the terminal filaments of the articular nerves. The pathology clearly pointed out by Vulpian has thus minutely been demonstrated by the facts of morbid anatomy. 2. In exceptional cases muscular atrophy is caused by extension of the inflammation from a bone or joint to terminal nerves supplying the muscles, or to the muscles directly. The atrophy of the limb is not limited to the muscles, but later nearly all of the tissues are concerned in the process. In advanced cases this atrophy proves obstinate to treatment, even after the bone- or joint- lesion has been completely cured, and on account of this the functional results are so seldom perfect.

Differential Diagnosis.—With few exceptions, a chronic inflammation in the epiphysial extremities of the long bones or in the body of a vertebra is of a tubercular character. In 95 out of every 100 cases, chronic inflammation in bone means tuberculosis, and, unless there are special reasons which should render the diagnosis doubtful, it is safe to adopt a treatment adapted for tubercular osteomyelitis in almost every case where

the symptoms point to a chronic inflammation, and the existence of syphilis and a tumor or parasitic growth can be excluded. In doubtful cases certain diagnostic measures should be resorted to, in order to enable the surgeon to make a positive differential diagnosis. One of these diagnostic resources is

Akido-peurastik.—Exploration of a doubtful swelling with a stout steel needle was introduced by Middeldorpf, for the purpose of ascertaining the consistence and probable structure of the tissue composing the swelling. He called this simple and often valuable diagnostic aid *akido-peurastik.* The presence of a tubercular focus in the interior of a bone can often be demonstrated by this harmless diagnostic resource before any external swelling has appeared. In place of a solid steel needle, a long and strong needle of an exploring-syringe can be used for puncturing a bone the density of which has been diminished by chronic inflammation, if this latter has not been succeeded by osteosclerosis. During the active stage of osteotuberculosis the bone, for a considerable distance around the focus, is osteoporotic, and can be readily penetrated by a strong, sharp, hollow needle. The exploration should always be made under strict antiseptic precautions, which always include thorough disinfection of the needle and of the surface where the puncture is to be made. The puncture is made in the centre of the tender area, and in a direction corresponding to the probable location of the central focus. If the needle meet with any considerable resistance in the bone it is advanced by rotatory movements; the arrival of the point in the granulating centre or caseous focus is announced by a sudden loss of resistance. By advancing the needle sufficiently to touch with the point the opposite side of the cavity its probable size and exact location can be ascertained. In tubercular necrosis, if the sequestrum is hard, the needle meets with greater resistance as soon as it has entered the cavity and has come in contact with the dead bone.

Inoculation Experiments.—If the needle of an exploring

or hypodermatic syringe is used to make the akido-peurastik, the exploration of the bone may be followed by removing some of the contents of the cavity by aspiration for examination. If the tubercular product has undergone caseation and liquefaction some of the cheesy material can be removed by aspiration, and the nature of the lesion may then be revealed by positive demonstration of the presence of the bacillus of tuberculosis. If still further evidence is required a guinea-pig can be inoculated with the same needle, which still contains enough of the material to produce a positive result in the animal. If the cavity contain granulation tissue, little fragments of this can be drawn into the needle, and with these inoculation experiments for diagnostic purposes can be made. If a tubercular abscess has formed, the character of the contents of the swelling can be determined by using the exploring-syringe, and the nature of the primary cause demonstrated, if need be, by injecting the material aspirated into the subcutaneous tissue or peritoneal cavity of a guinea-pig.

Probing.—Examination of fistulous tracts with a probe for diagnostic purposes has been, and still is, a much-abused practice. I must enter an earnest protest against the indiscriminate use of the probe in the exploration of fistulous tracts for diagnostic purposes. Septic infection can be produced not only through unclean instruments, but by means of the most carefully-disinfected probe. The granulating surfaces exposed to the air probably have upon their surfaces harboring places for different pathogenic bacteria. So long as the layer of granulations remains intact these microbes are harmless; as soon as the granulations are injured the lymphatic spaces are opened, into which the microbes pass and infect the surrounding tissues, or, perchance, the general system. They quickly multiply and initiate progressive septic processes. These dangers are diminished by careful disinfection of the wound as well as of the probe. Cauterization of the surface with nitrate of silver previously or simultaneously with the use of the probe, by coating

the latter with the melted salt, is an efficient prophylactic measure. In the differential diagnosis of tuberculosis of bone, it is necessary to exclude synovial tuberculosis, sarcoma, echinococcus cyst, rachitis, suppurative osteomyelitis, couchiolin osteomyelitis, and syphilis.

Synovial Tuberculosis.—Many cases of synovial tuberculosis have been mistaken for primary bone tuberculosis, and *vice versâ*. Primary tuberculosis of bone frequently results in contractures of joints without direct implication of the joint, and this has often led to a wrong diagnosis. In primary tuberculosis of the synovial membrane, the first pathological changes occur in the joint, and no tender points will be found in the epiphysial regions. In osteotuberculosis not complicated by an extension of the disease to the adjacent joint, the first symptoms are referred to the lesion existing in the interior of the bone, and it is usually not difficult to ascertain the existence of circumscribed points of tenderness which correspond to the location of the foci.

Sarcoma.—Periosteal sarcoma is, from the beginning, an extra-osseous product, and if it attack the shaft of a long bone it displaces the soft tissues instead of infiltrating them, as is the case in tubercular periostitis following primary bone tuberculosis. Central osteosarcoma, as a rule, increases more rapidly in size than a tubercular swelling, and is often the seat of pulsations on reaching the surface of the bone, and a blowing sound which can be heard by auscultation. Central sarcoma frequently gives rise to a pathological fracture, while this accident is exceedingly rare in osteotuberculosis.

Echinococcus.—Echinococcus of bone is a very rare affection, but, as it may simulate osteotuberculosis, a differential diagnosis between these two diseases can only be made by an exploratory puncture, which will yield a clear serum containing the characteristic hooklets in the former instance, and granulation tissue or the products of caseous degeneration in the latter.

Rachitis.—Rachitis is a disease of childhood, and is char-

acterized by swelling, pain, and tenderness in the epiphysial regions; but this affection is not limited to one or two bones, but affects alike almost every bone in the body. Profuse sweating is a constant symptom of rachitis, but seldom present in tubercular inflammation unattended by secondary infection with pus-microbes.

Epiphysial Multiple Osteomyelitis.—This is an acute or, at least, subacute affection, and results early in the formation of purulent foci, and is often attended by epiphyseolysis; with the exception of the upper epiphysis of the femur, the latter condition is seldom met with in osteotuberculosis. The joint complication in suppurative osteomyelitis is of the same nature as the primary disease in reference to the character of the inflammatory product.

Conchiolin Osteomyelitis.—Mother-of-pearl osteomyelitis was first described by Englisch. It is a plastic form of inflammation, and is caused by the presence of pearl-dust in the capillary vessels of the epiphysial extremities of the long bones in persons employed in the manufacture of articles of pearl. In a valuable paper on this subject Gussenbauer ("Die Knochenentzündung der Perl-mutterdrechsler." *Archiv f. klinische Chirurgie*, B. xviii) describes the entrance of pearl-dust into the circulation, and the manner in which the inflammation is produced. The artisans inhale the fine dust, which, in part, enters the pulmonary tissue in the same manner as fine coal-dust or microbes,—through the mucous membrane of the bronchial tubes. In the lungs minute particles of dust aggregate in small foci and excite slight inflammation around them. The dust is composed chemically of CO_2CaO and conchiolin. In the lungs the CO_2CaO is dissolved, and conchiolin remains as an insoluble substance. This substance enters the circulation and collects in the capillaries of the medullary tissue in the epiphysial region of the long bones, and leads to obliteration of some of the fine arterial branches. The osteomyelitis which develops around the infarcts spreads by continuity to the sur-

rounding bone, periosteum, and joints. The inflammatory product is of a plastic type; resolution and recovery follow, as a rule. Only in one case did the disease terminate in suppuration, and in this instance the primary conchiolin osteomyelitis undoubtedly became the seat of infection with pus-microbes.

Syphilis.—The virus of syphilis has a special predilection for the periosteum, while this structure is not very susceptible to primary tubercular infection. As a hereditary affection, syphilitic osteomyelitis of the epiphyses is not infrequently met with in newborn infants and young children.

Birch-Hirschfeld ("Beiträge zur pathologischen Anatomie der hereditären Syphilis Neugeborner Kinder," etc. *Archiv der Heilkunde*, Heft 2, 1875) found the characteristic pathological changes indicative of syphilitic inflammation of bone in thirty-five out of one hundred and eight stillborn children.

Haab ("Zur Kenntniss der syphilitischen Epiphysenlösung." Virchow's *Archiv*, B. lxv, Heft 3, p. 366) examined the conditions of syphilitic disease of the epiphysial extremities of the long bones in two stillborn children. In both of these cases epiphyseolysis had taken place, and the most striking pathological conditions were found in the epiphysial cartilages. In one of the cases the intercellular substance had undergone molecular destruction, while in the other, the condition pointed to an irritation which had given rise to active proliferation of the cartilage cells.

Taylor ("Syphilitic Lesions of the Osseous System in Infants and Young Children," p. 173) has written very clearly and precisely on the differential diagnosis between syphilitic and tubercular affections of bone.

"An important question here arises, namely: Are there any distinguishing characteristics in the osseous lesions which will enable the physician to promptly and correctly diagnosticate them from syphilis? It must be confessed that, in the main, they resemble in many particulars the lesion of syphilis; still, there are certain quite distinct features which are important

to know. As a rule, the osseous lesions above alluded to (those of acquired struma) are developed rather rapidly, may be complicated early by degeneration, and, for the most part, do not primarily affect the joints. There are usually a smaller number of bones involved than in syphilis, and there is a greater tendency to unsymmetrical development. Pain is generally a constant symptom, and, in short, there is usually a much more pronounced condition of inflammation than we find in syphilis. When degeneration occurs, there may follow sinuses which have the typical scrofulous appearance, which we have observed to be not constant in syphilis. Finally, a point of some importance may be determined by the bone or bones involved; thus, in this condition, it is very probable that the cranial bones would be unaffected, and that the lesion would be limited generally to the long bones or, perhaps, to the phalanges; whereas, in syphilis we have found that a number of different classes of bones were often coincidently involved. Still, as I have said in the chapter on diagnosis, the distinction very often rests upon the history of the case and upon the co-existence of lesions which are undoubtedly syphilitic. Treatment will not always afford conclusive evidence, but it may sometimes assist in a measure."

In doubtful cases, in which the results of treatment do not furnish positive diagnostic information, it may become necessary to resort to inoculation experiments in settling the diagnosis between syphilitic and tubercular affections of bone.

CHAPTER XII.

Prognosis of Tubercular Disease of Bone.

On the whole, the prognosis is more favorable in osteotuberculosis than if the tubercular infection is located in the skin, a joint, lymphatic gland, or any of the internal organs. Spontaneous healing of a tubercular focus in bone is possible under favorable conditions. Everything that adds to the patient's strength and power of resistance to the microbic infection adds to the possibility of such favorable termination. If the patient is well nourished, and, above all, if the blood is in a normal condition, limitation of the disease may occur before caseation has taken place; and, if cheesy material has formed, and can be removed by operative interference, the prospects of a permanent recovery are good. It must be, however, admitted that every person who has suffered from an attack of osteotuberculosis during childhood or youth, even if an apparent perfect cure has been effected spontaneously or by operative measures, is always in danger of becoming the subject of re-infection at any subsequent time. The spores of the bacillus of tuberculosis may remain in a latent condition for an indefinite period of time in the cicatrized primary lesion, to become a cause of subsequent danger as soon as the local or general conditions enable them to develop and exercise their specific pathogenic properties. Healing by cicatrization is possible in the small granulating foci, so long as the coagulation necrosis is limited and no caseation has occurred. In such cases the embryonal cells are converted into permanent connective tissue or bone, and the small fragments of bone are removed by absorption, while the bone around the cicatrix undergoes sclerosis. If caseation has occurred, and the cheesy material has not undergone liquefaction, encapsulation of the tubercular product can take place by the wall of granulation tissue lining the cavity becoming converted into cicatricial tissue, forming a capsule, which, for the

time being at least, mechanically prevents the local extension of the disease. Small sequestra may become imbedded in a connective-tissue capsule in a similar manner. Osteosclerosis around a healed tubercular focus adds an additional barrier to local extension and general infection. If the sequestrum is large, it will behave like every other foreign infected body, and sooner or later require an operation for its extraction. The appearance of tuberculosis in several bones simultaneously or in succession render the prognosis much more unfavorable than in cases in which the infection is limited to a single bone. If the tubercular process has extended to a joint the prognosis is also more grave, and the chances of a spontaneous recovery are much lessened. The prognosis is always more serious, other things being equal, if the bone affected is so located that elimination of the tubercular product is rendered difficult, and the removal of the primary focus by operative treatment is anatomically impossible. The danger to life and the probability of local extension are always greater if the granulation tissue has been destroyed by coagulation necrosis and caseation, as the granulation tissue is one of the means by which regional and general infection are prevented. The danger to life is imminent if a large tubercular abscess has become infected with pus-microbes, as the secondary infection results in destruction of the granulation tissue lining the cavity,—a condition which favors the local and general extension of the tubercular infection, and at the same time brings sepsis, exhaustion from profuse suppuration, and amyloid degeneration of important internal organs as additional elements of danger. The prognosis is always more unfavorable in persons advanced in years than in children, as limitation of the disease occurs more frequently in the latter.

Bone tuberculosis leads, in a certain percentage of cases, to infection of distant organs and general miliary tuberculosis. Re-infection of the body from a tubercular focus in bone takes place either directly through the veins or indirectly through the lymphatic channels. In young children tubercular meningitis

and general miliary tuberculosis often occur without any affection of the lymphatic glands on the proximal side of the focus, and in such cases the infection undoubtedly takes place by the entrance of bacilli or small fragments of infected tissue into the venous circulation. Very often, however, it can be seen that tuberculosis of an extremity diffuses itself through the body and becomes general through the lymphatic channels. Tubercular affections of the hand not infrequently give rise to similar affections of the cubital and axillary lymphatic glands. Quite as often tuberculosis of the knee and foot is followed by similar lesions of the inguinal glands, while tubercular coxitis gives rise to infection of the pelvic glands. If such glands are examined after extirpation, they always show the characteristic appearances of tuberculosis of these organs. Sometimes regional and general infection takes place by extension of the disease to a serous membrane; for instance, in cases of coxitis, where the disease has resulted in perforation of the acetabulum, the pelvic connective tissue is first infected, later the peritoneum is reached, and finally the patient dies of general miliary tuberculosis. Similar observations have been made in connection with tuberculosis of the vertebræ, sternum, and ribs.

The duration of the disease is an important matter, from a prognostic view. Spontaneous cures have been observed both in primary and secondary tuberculosis of bone. By cicatricial contraction the local focus is eliminated or rendered harmless. Large, wedge-shaped sequestra furnish an insurmountable barrier to definitive local healing without surgical interference. An apparently healed focus may remain harmless and latent for years, but later it can serve again as the starting-point of a new attack. Bone-lesions consisting of firm, dry granulations, without a tendency to caseation, terminate, under favorable circumstances, in recovery in from two to three years. Suppuration does not always affect the prognosis unfavorably. Small abscesses in bones and joints, in which otherwise the conditions of the granulations are favorable, heal by cicatrization, either

after spontaneous or artificial removal of their contents or by inspissation and encapsulation of the inflammatory product. The duration of osteotuberculosis is variable, and cannot be estimated with any degree of certainty, for without spontaneous or surgical removal of the tubercular tissue the local focus is always a source of danger. Amyloid degeneration of important internal organs only takes place after the tubercular lesion has become the seat of a chronic suppurative process. The last and greatest danger attending bone and joint tuberculosis is acute miliary tuberculosis. The tubercular embolus which blocks a small artery in wedge-shaped, tubercular infarct of the epiphysial extremities of the long bones must have passed through the heart, as it is not probable that it ever enters the arterial system directly. Such emboli are undoubtedly derived most frequently from tubercular thrombi in the pulmonary veins in the immediate vicinity of tubercular foci in the lungs. In all other instances the bacilli must pass the pulmonary capillary vessels. As it is not possible for fragments of tubercular tissue of any considerable size to pass through the pulmonary capillaries, it is probable that the embolus is composed of a small mass of bacilli, tied together with fibrin. Perhaps, also, a colony of bacilli aggregate at the point of bifurcation of a small artery in bone by mural implantation, and in this manner a tubercular thrombus is gradually formed, which completely obstructs the circulation to the area of bone supplied by the blocked vessel. In miliary tuberculosis millions of bacilli gain entrance into the circulation from a tubercular focus and localize in various organs, each point of localization becoming a miliary nodule. König has observed this termination only sixteen times out of thousands of cases of bone and joint tuberculosis that have come under his personal observation. In all of these cases the general tuberculosis followed operations for tubercular lesions. Miliary diffuse tuberculosis may and does occur without such an immediate cause. I have observed tubercular meningitis develop in young children on several

occasions, in the course of tubercular coxitis, without operative treatment, which shows that a tubercular focus in bone, undisturbed by operation, may become the distributing-point of bacilli, and constitute the immediate cause of metastatic tuberculosis in another organ, or general miliary tuberculosis.

CHAPTER XIII.

Treatment of Tuberculosis of Bone.

Early effective treatment of tubercular affections of bone is of the greatest importance, because the intrinsic tendency of the disease is toward progressive extension, and, if left to itself, sooner or later the appearance of serious complications is the rule, spontaneous recovery the exception. In some bones of the body the disease can be thoroughly eradicated by a simple and safe operation; in others, the anatomical location of the disease is such that a radical operation is out of question. As illustrations of the former class of cases, it is sufficient to mention tuberculosis of the phalanges of the hands and feet and of the malar bones, and, as an instance of the latter, the bodies of the vertebræ. The medical treatment in patients suffering from osteotuberculosis must be tonic and supporting. Dietetic and hygienic treatment is of more importance and value than the administration of drugs. Sea-bathing and change of climate will often accomplish more than bitter tonics, iron, quinine, arsenic, and codliver-oil. Experimental research has demonstrated that the internal and subcutaneous employment of some of the preparations of iodine retards the development and reproduction of the bacillus of tuberculosis in animals in which the disease was produced artificially, and experience has shown that the same preparations can be advantageously used in the treatment of different forms of surgical tuberculosis, including osteotuberculosis. A combination of potassic iodide with the syrup of iodide of iron has, in my experience, produced better results than any other method of medication. If digestion is not impaired, this medicine should be given in gradually increasing doses, until the iodine has produced its physiological effect, when the use of the drug is not suspended, but the dose reduced. The internal use of creasote, which seems to have proved of some benefit in the treatment of pul-

monary tuberculosis, deserves a trial in the treatment of bone and joint tuberculosis. Children suffering from osteotuberculosis should be carefully dressed, and the deleterious effect of sudden changes of temperature guarded against by enforcing the wearing of flannel under-clothing. Out-door air and a certain amount of exercise should be procured whenever the local disease does not furnish a positive contra-indication. Salt-water baths are of great value in such cases, as they stimulate the peripheral circulation, and, in so doing, prevent internal congestions. The local treatment, short of a radical operation, must consist in the use of such measures as will aid nature's resources in effecting limitation of the tubercular process, of which one of the most important is

Physiological Rest.—The importance of securing, as nearly as can be done by position and mechanical support, physiological rest for the inflamed part cannot be overestimated. The process of repair in a tubercular focus often meets with great and insurmountable difficulties. The embryonal cells, of low vitality almost from the very beginning, are poisoned, as soon as born, with the ptomaines of the bacillus of tuberculosis, and consequently are converted into tissue of a higher type only under the most favorable circumstances. The non-vascularity of tubercle-tissue is another cause why the inflammatory product so seldom takes an active part in the process of repair. The first indication in the treatment of a tubercular osteomyelitis is to secure for the part a favorable condition of the circulation, which can only be accomplished by rest. The most efficient way to procure rest, not only for the diseased part, but for the entire body, is to confine the patient to bed; but, as these affections are noted for their chronicity lasting for months and years, enforced rest by this method would seriously impair the general health, and the benefit derived from it for the local lesion would be more than overbalanced by the lack of fresh air and out-door exercise, and, on this account, it is advisable, in the majority of cases, to resort to one of the numerous me-

chanical appliances which will immobilize the part; while, at the same time, the patient can avail himself of the benefits to be gained from out-door air, change of scenery and surroundings. In tuberculosis of the spine it is often advisable to confine the patient to bed upon a Rauchfuss swing until the more acute symptoms have subsided, and, later, apply Sayre's plaster-of-Paris dressing. This method of making extension and of securing immobilization answers a better purpose than any of the numerous complicated apparatuses which have been as yet devised. To apply the jacket properly requires a great deal of experience and the exercise of considerable skill. In many communities this method of treatment has become unpopular, both among the physicians and the laity, from the bad results caused by improper application of the jacket and faulty extension. Hyperextension must be avoided, and the patient must be instructed to extend himself until he experiences relief, and no further. When this point has been reached the spine is immobilized in a plaster-of-Paris cast. Immobilization of joints with osseous foci in their vicinity is accomplished most effectually by the same kind of dressing.

Parenchymatous Injections.—The direct treatment of a tubercular focus in bone by the injection of antibacillary remedies fulfills the etiological indication. The success which has followed the injection of tubercular joints with iodoform and other antitubercular remedies should induce the surgeons to give this method a thorough trial in the early treatment of osteotuberculosis. I have recently made a number of such injections into the neck of the femur in cases of coxitis with osseous foci, and with results that encourage me to continue this method of treatment. A 10-per-cent. emulsion of iodoform or balsam of Peru should be employed for this purpose. This treatment will undoubtedly prove of great value in the treatment of granulating foci before caseation has occurred. If the parenchymatous injections are successful in sterilizing the infected tissue there is nothing further in the way of the inaugura-

tion of a reparative process; at the same time, further local and general infection need no longer be feared. If an osseous focus in one of the epiphysial extremities of the long bones can be located accurately the product of the tubercular inflammation can be easily reached and saturated with the iodoform emulsion.

The parenchymatous injection should be made with a large exploring syringe, with an asbestos instead of an ordinary leather piston. The needle should be stout, and sufficiently long to reach deep-seated foci. The strictest antiseptic precautions must be observed. The focus must be located as accurately as possible, and the puncture made in the manner previously described. From one drachm to half an ounce of the emulsion is to be injected; the injection of the latter quantity can only be made by using considerable pressure and proceeding with the injection very slowly, in order to gain time for the fluid to permeate the tubercular tissue in all directions. The iodoform not only possesses potent inhibitory antibacillary properties when employed in this manner, but at the same time stimulates the tissues around the infected area to active tissue-proliferation, which cannot fail in favoring the process of limitation and in expediting the reparative process. The injection should be repeated every two weeks, and is to be made from a different point every time, in order to saturate gradually the focus throughout with the antibacillary substance. The antitubercular action of iodoform is sufficiently well established by experimental research and clinical experience to warrant a trial with this remedy in the early stages of bone tuberculosis. Hueter advised parenchymatous injections of a 5-per-cent. solution of carbolic acid, and, more recently, solutions of corrosive sublimate have been used, but the results obtained with either of these remedies are less favorable than those following parenchymatous injections of a 10-per-cent. emulsion of iodoform in glycerin or pure olive-oil. Whether it is the iodoform as such which produces the curative effects, or whether it is the formic acid, as some claim, which is one of the products of the de-

composition of the iodoform in the tissues, is immaterial from a practical stand-point. I have not found it difficult to inject into tubercular osseous foci from one-half to one ounce of the emulsion, provided the injection is made slowly and a requisite number of deep punctures are made. The injection should be repeated every two weeks, and during the intervals the remaining part of the treatment so adapted as to place the affected part in the most favorable condition for the reparative process.

Ignipuncture.—Deep cauterization was introduced by Richet as a therapeutic resource in the treatment of bone and joint tuberculosis in 1870. ("De l'ignipuncture ou de la cauterization profonde avec des pointes de fer rouge dans le traitement des Arthropathies chroniques et des fungosités synovialis," *Presse Méd. Belge*, No. 29, 1870.) The instrument used first was an ordinary cautery iron with a bulbous extremity, and to the bulb was attached a short platinum point, two to three centimetres in length, like the needle-point of a Paquelin cautery. The instrument was heated in the ordinary manner, and the sharp point was plunged into the tissues far enough to reach the interior of the diseased joint or the focus in bone. The bulb was relied upon to furnish the necessary heat during the time required to make the puncture. He made from two to twenty-four punctures at one sitting, the number of the punctures being regulated by the size of the joint or bone and the extent of the intra-articular or osseous lesion. He applied the procedure, which he designates *ignipuncture*, in the treatment of chronic inflammation of bone and joints. The reaction following the operation is usually slight, and the after-treatment consisted of cold applications to the part operated on.

Kocher ("Zur Prophylaxis der fungösen Gelenkentzündung mit besonderer Berücksichtigung der chronischen Osteomyelitis und ihrer Behandlung mittelst Ignipunctur," Volkmann's *Klinische Vorträge*, No. 102) employed ignipuncture in the treatment of chronic osteomyelitis in 1872, before he had heard of Richet's work. He used a similar instrument, but with a longer platinum

point. The cautery, heated to a white heat, was pushed through the intact skin and softened bone into the osseous focus. Of eighteen cases treated in this manner, most of them made a rapid recovery; in others the cure was more protracted. One case died of pulmonary phthisis, the fistulous opening made with the cautery remaining open; two cases remained under observation at the time the report was made.

In opposition to Richet and Juillard, Kocher maintains that ignipuncture should be done in recent cases, and especially as a prophylactic measure when an osseous focus threatens to invade an adjacent joint. In such cases Kocher regards ignipuncture both as a curative and prophylactic measure, as, when it is resorted to early and properly, it not only often cures the primary lesion in the bone, but at the same time prevents the extension of the disease to the joint. It is interesting to know that ignipuncture, in the hands of Richet, Kocher, and others, yielded such happy results at a time when the operation was performed without antiseptic precautions. Invasion of tubercular foci with the knife at that time could not present such a favorable showing. This difference in the results was, of course, owing to the fact that in the former procedure the tissues were protected against infection from the tubercular focus within and the pathogenic microbes from without by the tubular eschar lining each one of the punctures. Ignipuncture, when practiced under antiseptic precautions, is a perfectly safe procedure, and a timely resort to it in cases of primary osseous tuberculosis will often be the means of preventing joint complications, and render more serious and mutilating operations unnecessary. Its use should be limited to the early treatment of osseous tuberculosis and tubercular affections of small joints. It should no longer be used in tuberculosis of the large joints. The benefits from ignipuncture are most marked when used before the tubercular product has undergone caseation; it is, therefore, most applicable during the early stage of bone tuberculosis. The instrument that is now used exclusively for this purpose is a

Paquelin cautery. If an accessible tubercular focus can be accurately located in the interior of a bone this method of treatment should receive a trial, as it is not attended by any risks, and frequently effects a permanent cure. The field of operation is thoroughly disinfected, and, with the needle-point of a Paquelin cautery heated to a dull-red heat, the soft tissues and bone are perforated. The compact bone over a tubercular focus has usually undergone such a degree of softening that it can be penetrated without much difficulty. In making the puncture it is necessary to advance the point slowly and to remove it from time to time, and revive the heat, in order to prevent impaction of the point. The entrance of the point of the instrument into the cavity or tubercular focus can be readily felt, as resistance at that moment is suddenly diminished. The therapeutic effect of ignipuncture is threefold: (1) the tunnel made establishes free drainage, and relieves promptly the intra-osseous tension; (2) the whole or, at least, a portion of the infected tissue is destroyed by the heat; (3) a plastic osteomyelitis is excited in the vicinity of the track made by the cautery, and in the cauterized portion of the cavity, which exercises a favorable influence in bringing about limitation of the disease, or even effecting a final cure. Through the opening made iodoform can be introduced into the cavity, which offers an additional advantage in treating osseous foci successfully by this procedure. If the tubercular focus is large, that is, larger than a hazel-nut, multiple punctures in different directions can be made through the same external opening, so as to destroy as much as possible of the infected tissue. To insure a successful issue it is absolutely necessary to prevent infection with pus-microbes through the opening by making the operation under strict antiseptic precautions and protecting the external opening with an efficient antiseptic absorbent dressing until it is completely closed by cicatrization and epidermization. Ignipuncture is most useful in the treatment of accessible foci in the epiphysial extremities of the long bones and during the early stages of tuberculosis

of the wrist and tarsus. In incipient tuberculosis of the tarsus I have repeatedly obtained a satisfactory and permanent result by making an opening through the entire tarsus from side to side, in a line of the disease, by inserting the point from each side, the two tunnels meeting in the centre. Ignipuncture always relieves the pain promptly, and the track made is carefully closed by permanent tissue in the course of a few weeks.

Removal of Osseous Tubercular Foci by Chiseling and Evidement.—While ignipuncture and parenchymatous injections of iodoform are only applicable in the treatment of bone

FIG. 20.—FISTULA OVER MIDDLE OF TROCHANTER MAJOR, LEADING INTO THE NECK OF THE FEMUR, IN A GIRL TWELVE YEARS OLD. (*Volkmann.*)

Fistulous tract was enlarged with chisel, and four sequestra and granulations removed. Perfect use of joint.

tuberculosis before the inflammatory product has undergone extensive caseation or sequestration, the mechanical removal of the infected tissue is indicated in all stages of the disease, and should always be done before the adjacent joint is invaded. The great danger to a joint, and the possibility of removing the osseous focus without opening the joint, is well shown in Fig. 20. The radical treatment of tuberculosis of bone consists in the complete removal of the infected tissues by operative interference. The success which follows this method of treatment is most marked in cases where caseation has not

taken place,—that is, in the granulating form, and in other forms where the operation is performed before extensive secondary pathological conditions have occurred. The operation of exposing a tubercular osseous focus with the chisel and removing the infected tissues with a sharp spoon is indicated as soon as a positive diagnosis can be made, and after milder measures have proved useless in arresting the progress of the disease. Timely surgical interference in osteotuberculosis is not only calculated to become the surest means of preventing general infection, but it also has for its object the limitation of the disease by the removal of the primary cause; and by accomplishing these objects it becomes at once a prophylactic as well as a curative measure. If a tubercular focus or foci can be removed by a radical operation before the adjacent joint has become infected, then the operation has not only been successful in effecting a permanent cure, but it has also been instrumental in preventing the extension of the disease to the joint.

If the operation is undertaken at a time, as it should be, before any external swelling has appeared, the surgeon must be guided in finding the focus by searching for tender points, aided, if necessary, by exploratory punctures. As in epiphysial tuberculosis the foci are always near a joint, the incision for exposing the bone should be made in such a manner as to avoid opening the joint. If the focus is so close to the joint as to make it necessary to remove bone underneath the insertion of the capsule or ligaments of the joint, it is advisable to lift the periosteum with the capsule from the bone to some distance from the incision, and in this manner avoid injury to the joint. The bone overlying a tubercular focus or abscess is usually softened and easily removed with a small, round chisel. The limb should always be rendered bloodless by using Esmarch's elastic constrictor, so that the operator can identify the tissues as they are being exposed and removed during the operation. If after tunneling the bone for a considerable distance the focus is not located, it is advisable to make from this track exploratory

punctures in different directions, with a small perforator, until it is found, when it is freely exposed with the chisel. As soon as this has been done the sharp spoon is used, with which the necrosed bone, granulation tissue, or cheesy material is removed. The osteoporotic bone in the immediate vicinity of the cavity is removed in a similar manner, and the operator must assure himself, by repeated examinations of the scrapings removed, that healthy tissue has been reached before the sharp spoon is laid aside. If any doubt remain whether all of the infected tissue has been removed it is better to resort to ignipuncture, perforating the bone at different points, to the depth of a few lines, with the sharp point of a Paquelin cautery in addition to the curetting. This procedure will destroy at least some of the bacilli which might have remained, and will incite a plastic osteomyelitis, that will effectually resist the pathogenic action of such microbes that still remain. After the cavity has been thoroughly irrigated with iodine water it is dried, iodoformized, and packed with antiseptic decalcified bone-chips. Iodoform is dusted freely between the chips. The periosteum is separately sutured over the bone-packing, sufficient space being left to insert at the lower angle of the wound a few threads of catgut to serve as a capillary drain. The remaining tissues are included in the superficial sutures and an antiseptic dressing applied. The limb must be immobilized by applying a well-padded, hollow, posterior splint. The limb should be kept in an elevated position for at least six to twelve hours. If all the infected tissues have been removed, and no infection with pus-microbes has taken place during or after the operation, the wound unites under one dressing in from one to two weeks, and the definitive healing of the cavity is completed in the course of three to six weeks, according to the condition and age of the patient and the size of the cavity. The packing of such cavities with iodoformized, decalcified bone-chips is an important element in the prevention of a local recurrence and general infection, and in securing satisfactory healing of the wound and complete

restoration of the lost parts. Should suppuration follow the operation, secondary implantation with decalcified bone-chips can be done successfully as soon as suppuration has ceased, and the cavity can be made thoroughly aseptic. Excision of a portion of the shaft of a long bone is only indicated in some cases of diffuse tubercular osteomyelitis below the knee- or elbow-joint where amputation is considered unnecessary. Extirpation of the entire bone affected is frequently called for in tuberculosis of the wrist, ankle, and tarsus.

Amputation.—A mutilating operation is often the only choice in the treatment of diffuse tubercular osteomyelitis, as it offers the only chance for complete eradication of the disease, and protection of the patient against general infection. It is contra-indicated in the other forms of osteotuberculosis, unless complicated by tuberculosis of an adjacent joint, and even in such instances it should be limited to cases that have passed beyond the reach of a typical or atypical resection.

CHAPTER XIV.

Tuberculosis of Joints.

Pathology and Morbid Anatomy.—Tuberculosis of joints, chronic fungous arthritis, strumous arthritis, and tumor albus are terms that even now are being used synonymously to indicate a form of inflammation of joints which is characterized clinically by its chronic course and the absence of acute signs and symptoms of inflammation. This affection is by far the most common joint disease that comes under the notice of the surgeon, so much so that König states that in surgical clinics the surgeon will have one hundred cases of tuberculosis to deal with to one of the other varieties of inflammation, such as gonorrhœal, syphilitic, suppurative, osteomyelitic, rheumatic, or the metastatic inflammation following acute infectious diseases. The first division of tubercular affections of joints upon an etiological and pathological basis must be made in reference to the primary location of the disease. The tubercular inflammation occurs either as a primary affection of the synovial membrane or as a secondary lesion in the course of an epiphysial bone tuberculosis. The comparative frequency of these two forms of joint tuberculosis has been frequently discussed, and even at the present time it cannot be said that the question has been definitely settled. The specimens derived from early resections have added largely to our knowledge on this subject, but it will require additional research in this direction before a final decision can be reached. Mr. Price ("A Description of the Diseased Conditions of the Knee-Joint," p. 134. London, 1865), from his own experience in the operative treatment of diseases of the knee-joint, is a firm believer in the frequency of the primary location of the disease in the articular ends of the bones, as may be judged from the following language: "I cannot help thinking that a large proportion of cases of chronic disease of the joint consist in a primary lesion of the cancellous structure of the long bones,

and I am the more inclined to this belief because, since excision has been frequently adopted in lieu of amputation for removal of diseased joints, greater opportunities have presented for a closer and more intimate acquaintance with the exact nature and origin of the disease." Other writers entertain an opposite opinion. Wiseman, who did so much to increase the knowledge respecting the white swellings of joints, which he was the first to describe, recognized—as we do now—the two different primary locations of the disease, as can be seen from the following quotation from his writings:—

"The swellings affecting the joints in this disease are of two sorts. Both of them are made by congestion and increase gradually, yet different in that the one ariseth externally upon the tendons and between them and the skin, or between them and the bone; the other internally, within the bone itself. That which ariseth externally affecteth the ligaments and tendons first, and sometimes relaxeth them to such a degree that the heads of the joints frequently separate from one another and the member emaciates and grows useless; but, for the most part, the tumor, overmoistening the ligaments and tendons, produceth a weakness and uneasiness in the joint, raising a tumor externally, and in progress the membranes and bones are corroded by reason of the acidity of the humor; yet it is much hastened if, upon a supposition of dislocation, they consult the bone-setters."

One of the strongest pleas in regard to the frequency of primary affection of the synovial membrane in strumous joint disease we find in the writings of the distinguished Cruveilhier ("Dictionare de Médecine et de Chirurgie pratiques," tome troisième, art. Articulations). This author expresses his opinion on this subject as follows: "Il est résultaté de mon observation que, dix-neuf fois sur vingt, ces maladies articulaires ne sont autre chose que des inflammations chroniques des synoviales; que dix-neuf fois sur vingt lors même que tous les tissues fibreux et cellulaires qui entourent une articulation ont été ehavis avec la synoviale qui a précede et qui domine."

Benj. C. Brodie ("Pathological and Surgical Observations on the Diseases of the Joints." London, 1850) described two conditions of the synovial membrane, and cited illustrative cases of each which now would be considered as typical joint tuberculosis. In one class "the synovial membrane had completely lost its natural structure, being highly vascular and much thickened, so that it projected into the articular cavity, covering the margin of the cartilaginous surface." In another class, in addition to these changes, "vascular fringes project from it into the cavity of the joint, which, in a more advanced stage of the disease, become converted into a number of membranous processes containing a fatty matter, and a good deal resembling, not only in appearance and in structure, the *appendices epiploicæ* of the great intestines."

Osteo-arthritis.—Primary tuberculosis of the synovial membrane leads to osteo-arthritis after the articular cartilage has become destroyed and the tubercular inflammation has attacked the articular ends of the bone; but this term is used to designate those cases of joint tuberculosis in which the reverse takes place,—primary osseous tuberculosis followed by tubercular inflammation of the joint. It is important to know how many cases of primary bone tuberculosis are followed by joint complications. König's operative experience has shown that a single focus near a joint can give rise to joint tuberculosis, and this is especially the case if the inflammatory area is large. In some cases of bone tuberculosis multiple foci are present at the same time, or form in rapid succession; thus, in caries sicca the foci are numerous, and give rise to extensive local defects. Granulating foci are more likely to occur as a multiple affection than the sequestrating form of bone tuberculosis. A combination of these two forms is of rather frequent occurrence. Among one hundred and fifty-four specimens from the hip, knee, and elbow examined by König, in ninety-five only one focus was found, while the remaining showed two or more. In this respect a difference is seen in the different joint specimens, as in the knee the number of single foci was twice as great as the multiple

lesions. In the hip-joint the number of each is about the same, while in the elbow only one-third of the cases presented multiple lesions.

The danger of extension of a primary osseous focus into a joint depends on the primary location of the disease. The nearer the osseous lesion is to the joint the greater the probability that it will extend in that direction and invade the joint.

After perforation into the joint has occurred, the tubercular material, as a rule, is brought in contact with the entire joint surfaces, and causes a diffuse tubercular synovitis. It sometimes happens that, by a coincidence of a number of favorable circumstances, general infection of the joint is prevented.

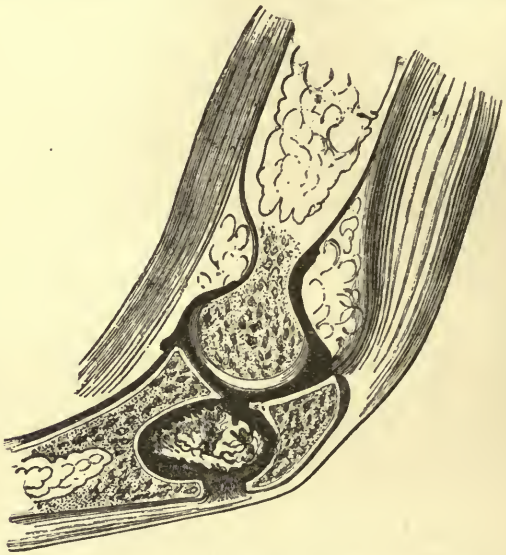

FIG. 21.—COMMON FORM OF OSTEOTUBERCULOSIS OF ELBOW-JOINT. (*Volkmann.*)

Patient, a girl eight years old. Fistulous opening over olecranon process. Perforation into joint, which is the seat of a fungous inflammation. Fistulous opening enlarged, sequestrum removed; joint incised and drained over head of radius; recovery, with perfect use of joint.

Such specimens bear evidence that invasion of the whole joint was rendered impossible by a plastic inflammation of the soft structures of the joint where perforation was about to take place, which resulted in isolation of the extravasated tubercular material and protection of the remaining portion of the cavity

of the joint by an impermeable wall of connective tissue. Such a favorable occurrence is most frequently observed in the knee-joint of children. More frequently, however, perforation into the joint is the cause of a speedy infection of the entire synovial surface. The tubercular synovitis is always most marked in recent cases around the perforation, and the process extends from here in all directions. Secondary tubercular synovitis

FIG. 22.—TYPICAL GRANULATION TUBERCULOSIS OF SYNOVIAL MEMBRANE WITH MANY ROUND AND OBLONG TUBERCLES, AND BETWEEN THEM STRIPES OF TUBERCULAR INFILTRATION. (*König.*)

appears in all forms which characterize the primary disease of this structure. Part of the granulations in a tubercular joint are not infected, but are the product of a plastic inflammation. Granulation tissue of this kind is often found underneath the articular cartilage, which it separates from the bone. The cartilage often presents a cribriform appearance, from the numerous small perforations made by the granulations upon and

underneath it. The behavior of the parasynovial tissue is characteristic. Œdematous infiltration is especially well marked in places where the subsynovial fat is abundant. The atrophic fat becomes œdematous from serous transudation. The tubercular granulations of the synovial membrane are friable, and show evidences of caseation. The granulations springing from the articular surfaces of the bones often present appearances of a tubercular nature as much as those in the synovial membrane. The tubercle-nodules are very numerous, imparting to the granulations a follicular structure. The ground-substance in which the nodules are imbedded is variable. Tubercles which manifest a tendency to rapid disintegration are imbedded in soft granulations infiltrated with round-cells, in which, besides the tubercles, isolated giant-cells are to be found. König describes in the tubercular synovial membrane, besides the common tubercle, a variety peculiar to this location.

Through the granulations traverse narrow, communicating streaks of epithelioid cells, giving an appearance as though the infiltration had taken place in pre-existing connective-tissue spaces. Often the impression gains ground as though the infiltration had occurred in the course of blood-vessels. Besides these granulations, tubercle-nodules are also found in the inflamed tissues, especially the connective-tissue spaces.

Primary Synovial Tuberculosis.—In synovial tuberculosis a series of pathological changes are initiated, in which all the structures of the joint are finally concerned, namely, the synovial membrane, parasynovial tissues, articular cartilage, and, lastly, the bone. The tubercle-nodule in the synovial membrane presents, under the microscope, the same histological structure as in other tissues. When the synovial membrane has become the seat of diffuse tuberculosis, the tissues undergo the same pathological changes as during the first stage of tuberculosis in other organs, and it is the characteristic granulation tissue that has given this form of arthritis the names of *fungous arthritis, fungous synovitis, and synovitis hyperplastica granulosa.* (Hueter.)

The tubercular nature of this form of synovitis was firmly established by Köster ("Ueber fungöse Gelenkentzündung." Virchow's *Archiv*, B. xlviii, p. 95), who showed, as early as 1869, that numerous miliary tubercles are regularly found imbedded in the granulations in every case of fungous synovitis, and that they can also be found with the same constancy in the walls lining fistulous tracts and in the membrane upon the wall of chronic abscesses. In the fungous synovial membrane he found them near the surface of the granulations, in a single layer, in the vascular and swollen tissues of the synovial membrane, or in the coverings of the articular fat. He showed, further, that, histologically, the nodules in the granulations are identical with the ordinary tubercle. He called attention to the fact that they undergo caseation. The nodules are arranged in groups, often so dense that they represent a glandular structure. In the deeper portions of the synovial membrane they become less numerous. The groups are usually supplied with a single vessel, of considerable size, which forms a net-work of capillary vessels around them. The periphery of the nodules is composed of lymphoid cells, which become larger and richer in protoplasm toward the centre. He found in the centre of each nodule one or more giant-cells. He even gave a minute description of the anastomotic projections of these cells. In nine cases of fungous synovitis the autopsy revealed no tubercle in any other organ, with the exception of one in which tubercular cavities were found in the apex of one of the lungs. The author reminds the reader that in the miliary form of tuberculosis caseation of the nodules takes place more speedily than in the synovial membrane.

König ("Die Tuberculose der Gelenke." *Deutsche Zeitschrift f. Chirurgie*, B. xi, p. 531) examined seventy-two diseased joints, and found in sixty-seven of them the characteristic appearances of tuberculosis. He found giant-cells so constantly that he asserts if they cannot be seen they are not found. Besides, in the granulation tissue he found tubercles in the

fibrous portion of the synovial membrane and in the fatty appendages of tubercular joints. The number of tubercles in different parts of the joint varies; they are found with the greatest certainty in the osseous foci, which are often composed of them entirely; at other times, the whole synovial membrane is permeated by nodules. In the peripheral portion of the articular cartilage they often appear in circumscribed tuberous form. In seventy-one cases of tuberculosis of joints he found the primary disease in bone forty-seven times. These early publications on the tubercular nature of most of the chronic affections of joints led other surgeons to make inquiries in the same direction, and confirmatory evidence of the opinion of these authors accumulated rapidly. During the early stage of the disease the surgeon meets with two distinct varieties; in one, the tubercular infection produces a pulpy condition of the entire synovial sac, with little or no effusion into the joint, the swelling being entirely due to the presence of a thick layer of granulation tissue,—the true tumor albus of the old writers. This form of tuberculosis gives rise, at an early stage, to extensive deformity of the joint, flexion, rotation, and, in the case of the knee-joint, partial dislocation of the tibia backward. In the other variety the fungous granulations are scanty, but a copious effusion takes place into the joint, giving rise to *tubercular hydrops*, which simulates a catarrhal synovitis, until time and the effect of treatment enable the surgeon to make a correct differential diagnosis. In this form, König assures us that he has never observed a tendency to flexion or any other form of displacement of the joint-surfaces. If suppuration take place, which is not often the case, it begins in the granulations which cover the synovial membrane, and the pus accumulates in the cavity of the joint, causing an articular empyema, until perforation of the capsule takes place. During the suppurative process the granulations are destroyed, and the tubercular infection penetrates deeper, and, as during the destructive process blood-vessels are destroyed, the patient is exposed to the

additional risks of general infection. If a tubercular joint open spontaneously, or is incised without observing strict antiseptic precautions, the additional infection from without leads to the most serious consequences, as, under these circumstances, pus-microbes are brought in contact with a surface that has been admirably prepared by the bacillus of tuberculosis for suppurative and septic processes.

Anatomico-Pathological Varieties of Joint Tuberculosis.— The classification of tubercular affections of the joints on an anatomico-pathological basis is made in reference to the character of the inflammatory product. This varies according to the extent and intensity of the disease and the stage of the retrograde degenerative changes. The histological structure of the tubercular product, as revealed under the microscope, is the same during the early stage of tubercular synovitis, but the abundance of new tissue and the differences observed in the rapidity with which the inflammatory material undergoes coagulation necrosis, caseation, and liquefaction of the cheesy material in different cases are conditions which characterize the different pathological varieties which will now be enumerated and described.

Classification upon such a basis is of great practical importance, as upon it depends the adoption of appropriate treatment in any given case. For instance, a tubercular synovitis without caseation would indicate expectant treatment by rest and the use of intra-articular injections, and if this treatment fail an arthrectomy would in all probability yield a favorable result. On the other hand, if the synovial tuberculosis has destroyed the articular cartilage, and has involved the articular extremities of the bones, the prospects of recovery under expectant treatment are reduced to a minimum, and if operative interference is decided upon an atypical or typical resection becomes an unavoidable necessity.

Acute Miliary Tuberculosis of the Synovial Membrane.— König describes a form of tuberculosis of the synovial membrane in which miliary tubercles are found in the subsynovial

tissue, and in which the synovial membrane is not at all altered. There are no symptoms of disease of the joint. This condition occurs in acute general tuberculosis, and is like the same affection in bone, only of pathological interest. A correct diagnosis is only possible in the post-mortem room. Primary, diffuse miliary tuberculosis may present itself with or without an osseous focus; if the latter is present it does, however, not communicate with the joint, and occurs simultaneously with the joint affection. The local conditions are variable. In one form small gray tubercles are scattered through the deeper layers of the synovial membrane, while its surface has undergone little or no alteration and the joint remains useful, and the patient makes no complaint and presents no other indications of the existence of the joint-lesion. In other instances granulations do not form, and the only evidence that points to the existence of the tubercular joint affection is a slight hydrops of the joint.

Tubercular Hydrops.—A tubercular affection of the synovial membrane giving rise to a copious effusion into the joint is called *tubercular hydrops.* Pathologically this form of joint tuberculosis bears a strong resemblance to tubercular ascites. Macroscopically the synovial membrane presents but slight alteration, as the tubercle-nodules are few and imbedded in the synovial membrane. Within a short time the joint becomes distended with fluid, but pain is slight or altogether absent, and the patient is able to use the limb. The fluid withdrawn by tapping or aspiration resembles the normal synovial secretion; sometimes it is less viscid and contains small shreds of lymph, which have become detached from the surface of the membrane. After removal of the fluid the normal size and contour of the joint are restored. Re-accumulation, as a rule, takes place rapidly, and after a few days the effusion is as copious as before the tapping. In other cases the fibrinous deposits are more abundant; then we speak of a *hydrops fibrinosus.* It seems that during the early stages of this variety of joint tuberculosis the inflammation disturbs the equilibrium between secretion

and absorption of the synovial fluid, which is in all probability accomplished by a specific form of alteration of the vessel-walls, permitting free transudation, while at the same time the absorptive capacity of the joint is impaired. Thickening of the synovial membrane takes place later, and ultimately the joint presents the characteristic appearances of tubercular synovitis. A correct diagnosis in these cases is often only possible by the subsequent clinical course of the disease.

A painless, rapidly-forming mono articular hydrops is always a suspicious affection, and, if the case prove rebellious to ordinary treatment, a suspicion of its tubercular nature should always be entertained, and this suspicion always becomes well grounded if, after the hydrops has disappeared spontaneously or under appropriate treatment, the joint remains swollen and presents other indications of the tubercular character of the inflammatory product. For the remaining forms of tubercular synovitis Hueter's (*Klinik der Gelenkkrankheiten*, Leipzig, 1876) classification still remains as the best.

Synovitis Hyperplastica Lævis S. Pannosa.—In this form the synovial membrane is only slightly thickened and vascular, and its surface remains smooth. The tubercle-nodules are extremely small, rarely visible to the naked eye, and widely disseminated over the entire or greater portion of the synovial sac. Under the microscope the intima is seen to be composed of several layers of cells, and between them exists a well-marked system of juice-canals. The synovial membrane is not only thickened, but its surface at the same time is greatly increased at the expense of the articular surfaces. From the border of the cartilage a thin, vascular layer of granulations approaches the centre of the surface of the joint somewhat in the manner a pannus invades the cornea. Those parts of the articular surfaces which, in the embryo, are covered by a physiological pannus are first the seat of this pathological process, which resembles the former macroscopically and microscopically.

Synovitis Hyperplastica Granulosa.—This variety appears

to be only a more advanced stage of the preceding. They further resemble each other in that hydrops does not occur in either of them. In this form of joint tuberculosis the synovial membrane is affected throughout, being considerably thickened and hyperæmic, and covered by a more or less thick layer of velvety granulations. The abundance of granulation tissue which is always present in this type of synovitis induced Billroth to apply the term *fungous synovitis*. The granulations are produced by proliferation from the intima of the synovial membrane. The granulations resemble somewhat the granulations of an open wound, but differ from them by being less vascular. The synovial granulations are pathological products, and do not tend to undergo cicatrization. The tubercle bacilli imbedded in the granulations retard the growth of young blood-vessels, and in this manner determine early degenerative changes of the inflammatory product. The ligaments and para-articular structures are affected at a comparatively early stage, and thus is formed the thick, œdematous mass of tissue, usually of a gelatinous appearance, in which, here and there, cheesy foci are found. In the beginning of the disease a microscopical examination of sections of the synovial membrane will show that this structure is divided into two parts,—an internal layer, where the tissue is soft and, at an early stage, villous, and later covered with caseous material, and an external or firmer layer, without caseation. The soft layer does not always cover the whole surface, and can be frequently rubbed off, with very slight pressure. The relative thickness of these two layers varies greatly in different specimens. In a second type no such distinction in layers can be made, the synovial membrane being composed essentially of the firmer tissue, but the surface is infiltrated with tubercle-nodules in various stages of degeneration. In a third variety of cases there is much thickening of the synovial membrane and subsynovial tissues, which often appear œdematous, and the tubercles, if present, are usually limited to the vicinity of osseous foci. In this variety of syno-

vial tuberculosis infection takes place on the surface, and extends from here to the deeper tissues; while caseation is taking place on the surface of the membrane the process extends into the substance of the membrane and the tissues outside of it. In advanced cases the two layers of the synovial membrane are no longer distinguishable, as the degenerative changes have brought about coalescence. In another variety, as in simple hyperplastic synovitis, tubercles are not deposited primarily on the surface of the synovial membrane, but in its substance and underneath it. During the progress of the disease the whole thickness of the membrane becomes involved, and after this has occurred the condition resembles the cases in which primary localization occurred upon the surface of the intima. In such cases caseation takes place later, and the formation of abscesses is of less frequent occurrence. In the third type of diffuse synovial tuberculosis the tubercles, which are few in number, are deposited in the fibrous portion of the synovial membrane. In some places the membrane is much thickened, but contains no tubercles, the swelling being due to the presence of an exudation resulting from a plastic inflammation caused by and accompanying the tubercular process. This form may originate as a primary synovial tuberculosis, but more frequently it follows in connection with osseous foci which have not yet reached the surface. It is important to determine the extent of the disease in the operative treatment of joint tuberculosis, as it is now generally conceded that operations should be limited to the removal of diseased tissues. If infection has not extended beyond the limits of the synovial membrane an arthrectomy is indicated; but if the disease has reached the structures outside of it, an atypical or typical resection is indicated.

Synovitis Hyperplastica Tuberosa.—This is a comparatively rare form of joint tuberculosis, and a positive anatomical diagnosis is usually a post-operative or post-mortem revelation. This affection of the synovial membrane was first described by Riedel and König. The tubercular inflammation results in the

formation of circumscribed, subsynovial masses, which may attain the size of a walnut, projecting into the joint and filling, for instance, the supra-patellar recess of the knee-joint. The

FIG. 23. (Half natural size.)

FIG. 24. (Natural size.)

FIG. 25. (Natural size.)

SECONDARY TUBERCULOSIS OF KNEE-JOINT. GREAT HYPERTROPHY OF SYNOVIAL AND SUBSYNOVIAL TISSUES. (*Krause.*)

All three specimens removed from the same joint. In Fig. 25 the tubercle-nodules can be distinctly seen.

disease is attended by simple irritative synovitis or pannous synovitis in the rest of the synovial membrane. In the typical form of tuberous synovitis the infection is limited, and the operative removal of the fibrous swelling or swellings results in

a permanent cure. In other cases the affection is more diffuse, the foci of infection and hyperplastic inflammation numerous, giving rise to papillomatous plastic synovitis, where the whole inner surface of the synovial membrane is covered with sessile or pedunculated papillomatous growths, small and rather uniform in size, some of which may become detached, when they constitute the so-called rice-bodies. This condition of a joint has also been described as *lipoma arborescens tuberculosum*. Clinically it is a form of joint tuberculosis in which the pathological product appears as a firm swelling, with little tendency to softening and caseation. It is found most frequently in the knee-joint, and occasionally, also, on tendons and in tendon-sheaths. Riedel describes the characters of these cases as follows: "The synovial membrane is reddened, often thickened, and shows one or more firm prominences on the surface; the joint frequently contains fluid and rice-like bodies; the nodules contain numerous tubercles, often closely packed together." The anatomical structure of the inflammatory product is variable. Frequently it is found as a single swelling, the size of a hazel-nut, more or less flattened, and develops from the fibrous portion of the synovial membrane. The structure is firm, of a grayish-red color, infiltrated with light-gray nodules, the size of a pin's head. *The swelling is completely covered by the intact intima.* Microscopically the bulk of the mass is composed of young connective tissue, partly in a state of fatty degeneration, bounded by a layer of firm connective tissue. The defective blood-supply leads to early degenerative changes. In the deeper portions of the swelling remnants of tubercles are found, while in the vascular portion tubercles are numerous. In some places numerous degenerated blood-vessels can be found. These vessels have thickened walls, and the capillary vessels are surrounded by many layers of spindle-shaped cells. In the inflamed tissues between the vessels tubercle-nodules are always present. In some specimens portions of the swelling present an angiomatous appearance, the

vessels being very numerous and the cellular elements scanty. In this form of joint tuberculosis there is always a tendency to deposition of fibrinous masses in the interior of the joint. When this occurs the synovial membrane becomes thickened over the tubercular product, which always increases the size of the swelling. In some specimens the whole surface of the synovial membrane is covered with papillomatous formations. The tuberous form of synovial tuberculosis is always a local infection. The inflammatory product in the interior of which the tubercles are located is the result of a local disease.

Tubercular Empyema of Joints.—The pathological condition of tubercular joints for which König proposes the name *synovitis suppurativa tuberculosa* is comparatively rare. Tubercular pyarthrosis of joints is observed in different anatomical forms. The most typical form which corresponds very closely to the cold abscess of the old authors is the one in which the synovial membrane is attacked with diffuse tuberculosis without the production of copious granulations. Less characteristic are the cases in which the same condition is established in joints which contain a thick layer of granulation tissue. The first form is met with most frequently in the knee-joint of children, less frequently in the hip-joint. In children the abscess develops often very rapidly, resembling in its clinical history hydrops or acute suppurative synovitis. It attends most frequently primary diffuse synovial tuberculosis, and is less frequently associated with secondary infection of a joint from an osseous focus. The tubercular abscess of joints is an advanced stage of the other varieties of tubercular synovitis. The tendency to caseation and liquefaction of the cheesy material varies greatly in the different forms of joint tuberculosis. As a rule, these retrograde degenerative changes are slow to appear in cases in which the tubercular inflammation results in the production of an abundance of granulation tissue, and they are most prone to occur in cases of diffuse tuberculosis of the synovial membrane attended by scanty proliferation of tissue. In the typical tuber-

cular empyema of joints the synovial membrane and capsule are not much thickened, and offer but little resistance to the intra-articular pressure; the joint is, therefore, often enormously swollen, and the capsule greatly distended. The inside of the capsule is covered with a loosely-adherent tubercular membrane, similar to that in tubercular abscesses. The superficial granulations which compose this membrane have undergone degenerative changes. Outside of this membrane the

FIG. 26.—RESECTED UPPER END OF FEMUR. (*Volkmann.*)

Tubercular foci immediately under the articular cartilage, which is separated, hood-like, from the bone by the suppuration. *a*, cribriform perforations of the cartilage.

tissues are diffusely infiltrated with miliary tubercles, but the infection does not extend beyond the synovial membrane. The fluid in the joint, like in all tubercular abscesses, is not pus, but serum, in which we find suspended the products of coagulation necrosis. With the extension of the tubercular process beyond the limits of the synovial sac, the articular cartilage and, finally, the bone are successively attacked. The articular cartilage takes no active part in the inflammatory process,—it is detached and removed by the granulations. An osseous

focus in contact with the cartilage usually makes a circular defect through which the granulations or cheesy material can be seen. The cartilage covering a tubercular infarct is rapidly destroyed, and is mechanically detached in smaller or larger fragments. In primary tuberculosis of the synovial membrane the process usually commences at the periphery of the articular cartilage, and from here the granulations dip down into the vascular bone, and often undermine the cartilage extensively before any destructive changes are witnessed on the side directed toward the joint. In such cases the cartilage is not only extensively detached, but perforated at numerous points by the granulations underneath it. The action of the granulations on the articular extremities of the bone produces a condition which has been described for centuries as caries. *Caries is not a disease, but the result of a disease. The bone becomes softened, and by molecular disintegration, caused by the action of the granulations, it becomes porous and honey-combed.*

Numerous miliary nodules can be seen in the affected area which, in the course of time, undergo coagulation necrosis and caseation. In long-standing cases the destruction of bone is so extensive that in the hip-joint, for instance, it may result in the loss of the entire head of the femur and perforation of the acetabulum. The fluid in abscess of a joint is an emulsion composed of liquefied cheesy material, fragments of degenerated tissue and detached particles of cartilage and bone if the tubercular process has involved these structures. The joint-abscess, under favorable local and general conditions, sometimes develops speedily and early; at other times it appears slowly, and months and often years after the inception of the primary disease.

CHAPTER XV.

Special Points in the Pathology of Synovial Tuberculosis.

Rice-Bodies.—Loose bodies in the joint, the so-called rice-bodies, are now known to be of a tubercular nature, resulting from a formation of new tissue usually on the surface of the synovial membrane. The larger *corpora mobilia* have, as a rule, a traumatic origin. If the trauma has not split off completely a portion of the articular surface, an occurrence which Schuchardt thoroughly described, cartilage or cartilage and bone, it results in inflammatory changes which later accomplish the separation. Klein (Virchow's *Archiv*, B. xxix, p. 190) has called this latter process "spontaneous demarcation"; Kragelund (*Centralblatt f. Chirurgie*, 1887, p. 412), "ostitis"; Broca, "necrosis of cartilage"; and König, "osteochondritis dessicans." That the process is not of a necrotic nature is evident from the fact that some of the loose bodies show evidences of proliferation, and sometimes increase in size after their detachment, the nourishment being furnished by the synovial fluid.

The minute structure and tubercular nature of the so-called rice-bodies, *corpora oryzoidea*, so frequently present in tubercular joints and tendon-sheaths, were first accurately described and pointed out by Riedel ("Zur Ætiologie der fibrinösen Fremdkörper im Knie." *Deutsche Zeitschrift f. Chirurgie*, B. x). These bodies vary in size from a cucumber-seed to a melon-seed, and in color and consistence resemble the grains of boiled rice. Their presence in a joint or tendon-sheath is almost a sure indication of the tubercular nature of the disease of these structures which produce them. According to König ("Die Bedeutung des Faserstoffes fuer die pathologische Anatomie und die Entwickelung der Gelenk und Sehnenscheiden tuberculose." *Centralblatt f. Chirurgie*, B. xiii, No. 25), these bodies are composed almost exclusively of fibrin. He believes that fibrinous exudation is one of the constant products of tubercular inflam-

mation of joints and tendon-sheaths, and that these bodies are fibrinous concrements varying in size and number in accordance with the abundance of the exudation. The copious fibrinous exudation of the synovial membrane which, in some forms of joint tuberculosis, characterizes the type of the disease is well shown in Fig. 27.

It is very easy to see how, in cases of this kind, loose bodies form by separation of these projections. Schuchardt ("Ueber die Reiskörperchenbildungen in Sehnenscheidem und Gelenken." Virchow's *Archiv*, B. cxiv, Heft 1, p. 186), in a lengthy and exhaustive treatise upon the origin, formation, and nature of these bodies in joints and tendon-sheaths, maintains that they are not composed of ordinary fibrin, and cannot be considered in any case to be produced by coagulation necrosis of the inflammatory material deposited upon the surface of the internal wall of the cavity of the joint or tendon-sheath. He does not believe that the villous and papillomatous growths found within some hygromas are the main cause of the free riziform bodies often associated with this condition; for, even where such villous outgrowths are present they may bear no relation to the free bodies, and the rapidity with which these bodies sometimes reform after the sac has been evacuated argues against their passing through a stage of villous excrescence. Indeed, he has found the wall of a ganglion largely composed of agglutinated and flattened, half-formed rice-bodies. The size and form of these bodies are doubtless mainly determined by the movements to which they are subjected, so that when mobility of the parts is slight they form less readily than when

FIG. 27.—EXTIRPATED PIECE OF CAPSULE OF KNEE-JOINT, SHOWING NUMEROUS PAPILLOMATOUS PROJECTIONS. (*König.*)

it is free and marked. Examined by Jalagnier, they were found to be developed upon the surface of the synovial sheath; later, being pushed out, and finally becoming detached from the surface upon which they originated.

Tillmanns ("Beiträge zur Histologie der Gelenke," *Archiv f. Mikr. Anatomie*, 1874, B. x, pp. 425–436) has described, from a histological point, synovial villi or papillæ composed of myxomatous, fibrous, fibro-myxomatous, and adipose tissue, all having the common structure of being covered by several layers of intima-cells. The proliferation evidently takes place from the adventitia of the synovial membrane. The more these papillæ project into the joint, the more the cellular covering suffers from pressure and friction. The tissue of which they are composed resembles more and more fibroma, and after they project some distance beyond the surface pedunculation takes place, and the papillary fibroma of the synovial membrane, as described by Virchow (*Die Krankhaften Geschwülste*, Berlin, B. i, p. 340), has formed. The synovial membrane is often found covered by hundreds and thousands of such papillary excrescences.

Wallich (*La Semaine Médicale*, November 21, 1888), though unable to discover bacilli in rice-bodies, succeeded, by inoculation, in producing tuberculosis in guinea-pigs with them. I have repeatedly verified the tubercular nature of such loose bodies in tubercular joints and tendon-sheaths by successful implantation experiments.

Tubercular Chondritis.—The absence of blood-vessels and other vascular spaces in cartilage is the reason why this tissue is seldom the seat of a primary tuberculosis. Cartilage is, in every sense of the word, a non-vascular structure, as even the plasma-channels found in the cornea are absent here. Nutrition of this structure must take place exclusively by imbibition between or through the cells. That such parenchymatous diffusion through this tissue takes place was known to Cruveilhier, who injected ink into the joints of animals, and found some time

afterward that the cartilage was deeply stained, while the ink had been removed from the synovial sac by absorption. In the same manner living cartilage can be stained a red color by injecting into joints a borax-lithion-carmine solution. While normal cartilage is an avascular structure, it is supplied with blood-vessels from the perichondrium, like the cornea from the pericorneal blood-vessels when the seat of irritation or inflammation. Gussenbauer studied the repair of cartilage wounds experimentally on costal cartilage of animals. He made subcutaneous incisions, and then examined the specimens from a few hours to several weeks after the injury had been inflicted. In wounds twenty-four hours old a triangular gap was found, filled with fibrin and blood-corpuscles. No change was found at this time in the cartilage cells and cement-substance. Evidences of beginning repair he found in the vascular perichondrium, the cells of which had increased in size and changed in form. He was unable to verify the observations made by Reitz, in wounds of the trachea, that cartilage cells are transformed into connective-tissue cells, and believes that the ammonia used by Reitz to provoke croupous pneumonia, by its introduction into the bronchial tubes through the tracheal wound, may have modified the result. He traces tissue-proliferation almost exclusively to the perichondrium, the cells of which were found in all stages of division and development, while only a few of the cartilage cells presented evidences of karyokinetic changes. Dorner studied not only the manner of repair of simple incised wounds of cartilage, but also produced more complicated injuries, and invariably found that the perichondrium took a more active part in the process of healing than the cartilage cells. The histological changes observed by Redfern, Dorner, and Gussenbauer, during the repair of wounds of cartilage produced experimentally, are descriptive of the minute anatomy of chondritis. In the early stages of pannous synovitis the articular cartilages are supplied with blood from the synovial membrane, and in other localities the inflammatory process begins, like the

suppurative process, in the perichondrium, and invades the cartilage a little in advance of the net-work of new blood-vessels. That a tubercular perichondritis occurs as a primary affection I have had repeated opportunities to verify. In all of the cases of this kind that have come under my observation the disease involved the costal cartilages. The following case will serve as an illustration :—

The patient was a man 46 years of age, without any hereditary predisposition to tuberculosis. He was admitted into the Milwaukee Hospital February 6, 1891, and operation was performed on the same day. The patient is quite obese, and the general appearance would not lead to the suspicion that he is the subject of a tubercular affection. Preceding year, during the month of July, he suffered from an attack of typhoid fever. About a month later, after considering himself fully convalescent, be began to experience an intermitting pain under the left breast, which extended backward toward the spine. In September a swelling appeared over the cartilages of the seventh and eighth ribs. With the appearance of the swelling the pain gradually subsided. On admission this swelling had attained half the size of an adult's fist, and presented the usual appearances of a cold abscess. Although the patient presented every evidence of unimpaired health, I suspected that the abscess had developed in the course of a primary tuberculosis of one or more ribs. The external surface presented a healthy appearance, but the skin was firmly attached to the deeper tissue by inflammatory adhesions. The patient complained of no pain, and tenderness on pressure was only slight. A semilunar incision was made through the skin and superficial fascia, the convexity directed downward so as to expose the field of operation freely after reflection of the flap. The subcutaneous tissue was somewhat œdematous. Incision through the pectoral muscles evacuated about four ounces of tubercular pus. The abscess-cavity was lined with fungous granulations. Two fistulous tracts led down to the cartilages of the seventh and

eighth ribs. Sternum and ribs intact. Both cartilages were removed in their entirety. Examination of the specimens showed that they were denuded of perichondrium on the anterior surface, and each of them presented superficial defects, the size of a pea, partly filled with granulation tissue. The abscess-cavity was thoroughly scraped, iodoformized, and the external wound sutured, after making provision for capillary drainage. The entire wound healed by primary union, the patient has remained in good health, and there has been no sign of local recurrence. It is more than probable that in this case the disease commenced as a tubercular perichondritis; and yet one or two cavities were so deep and their opening on the surface of the cartilage so narrow that the appearances suggested a primary focus in the cartilage, with secondary involvement of the perichondrium and surrounding tissues. In another case I found the costal cartilages of six ribs the seat of extensive tuberculosis, while the ribs and sternum were intact. A thorough scraping operation, under strict antiseptic precautions, resulted in a speedy and permanent cure.

Kocher has described in the knee-joint *meniscitis tuberculosa* as a primary tuberculosis of the semilunar cartilages, but there is no positive evidence that the disease did not commence in the synovial membrane covering these structures. In tuberculosis of joints the alteration of the articular cartilages is caused by the action of tubercular tissue upon them from the synovial membrane, or from the subjacent bone, the cartilage taking no active part in the process. The cartilage is often completely destroyed by the granulations which frequently act upon it from both sides.

It is removed by the granulations somewhat in the same manner as a disc of aseptic decalcified bone, only that its absorption is accomplished by a much slower process. The most common changes found in it are thinning and multiple defects. These changes are most marked and appear earliest where the synovial membrane joins the cartilage, as at the edges of the

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cartilage, at the points of attachment of the crucial ligaments in the knee-joint, in the neighborhood of the ligamentum teres in the hip-joint, etc. In primary disease of the synovial membrane the cartilage often remains intact for a long time in all cases in which the intrinsic tendencies of the disease are to remain limited to the synovial structure, while in others the extension of the tubercular process to the cartilage is an early occurrence. The chondritis is preceded by extension of the vascular synovial membrane in the form of a pannus over it, which converts the cartilage first into fibro-cartilage and later into fibrous tissue, and the new tissue then formed becomes subsequently infiltrated with

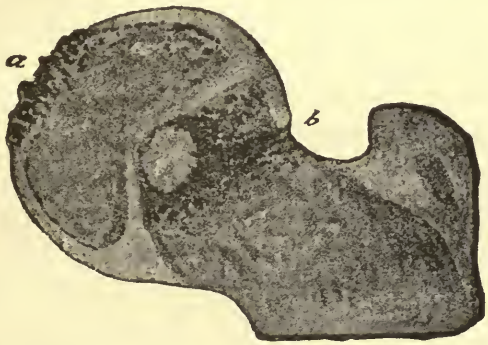

FIG. 28.—PRIMARY OSSEOUS TUBERCULOSIS OF HEAD OF FEMUR. (*Krause.*)
Perforation into joint at *b*; secondary synovial tuberculosis which has resulted, at *a*, in circumscribed destruction of articular cartilage.

tubercular tissue from the synovial membrane or bone, and undergoes the characteristic degenerative processes. At some points the soft tissues proliferate more actively, and thus islets of granulation tissue are seen to fill minute excavations in the cartilage. At other points the granulations from the end of the bone undermine and separate the cartilage. In primary osseous tuberculosis of the articular extremities the subchondral foci detach and elevate (Fig. 26) the cartilage; this separation is often quite extensive, as the tubercular process between the bone and cartilage is often diffuse before perforation takes place and keeps on extending after this accident has occurred. The osseous focus, when it has reached this locality, gives rise to

granulating osteomyelitis of the articular surface of the bone, which, as a rule, involves the bone only to a depth of a few millimetres, and only in exceptional cases is the entire head of the bone affected. The detached cartilage becomes macerated by the tubercular product in the joint. In tubercular infarcts invading joints the cartilage covering the base of the wedge-shaped sequestrum is destroyed early, and if the patient continues to use the limb the articular portion of the necrosed bone presents a dense, polished surface. In diffuse tubercular osteomyelitis, if the plate of articular cartilage is detached, the exposed surface of the bone will be found covered with pale, red, flabby granulations growing out from the bone. If the disease has extended at the same time to the medullary cavity the marrow appears very vascular, as it has been transformed into granulation tissue,—a condition which König has observed most frequently starting from the shoulder-joint, involving the shaft of the humerus.

Weichselbaum ("Die feineren Veränderungen des Gelenk knorpels bei fungöser Synovitis u. Caries der Gelenkenden." Virchow's *Archiv*, B. lxxii, p. 110) has studied and described with great care the minute tissue changes which take place in the articular cartilages in tubercular joints. In tubercular synovitis an inflammatory process is initiated in the periphery of the cartilage, and at first in the most superficial cells, which consists in the proliferation of new cells. The new cells are granular, nucleated, and provided with processes. The spaces in which these cells are found become enlarged and confluent, and result in the formation of minute linear depressions on the surface. In this manner a sort of granulation tissue is formed, which coalesces with the synovial granulations. In this way the cartilage may become completely destroyed, the process extending from the periphery toward the centre. In caries of the articular ends the cartilage cells nearest the bone undergo regressive metamorphosis, and their place is taken, step by step, by granulation tissue springing from the medullary spaces.

According to Weichselbaum, at a later stage the cartilage cells take an active part in the inflammatory process, and the granulations from both sources meet and form a common subchondral product.

Pathological Changes in Bone in Joint Tuberculosis.—The gravity of the secondary bone-lesions depends on the extent and duration of the disease. Atrophy of the bone is a conspicuous feature in all cases of long standing, and more especially if the location or extent of the disease has necessitated prolonged and enforced rest. Such specimens present characteristic appearances, the cortical portion being very much thinner than in the normal condition, and the spongy portion greatly rarefied and softened. *Not infrequently, simple atrophy has been mistaken for disease, and an unnecessary amount of tissue has been sacrificed in resections and amputations for tuberculosis. These changes are not the result of inflammation, but develop in consequence of defective nutrition incident to long-continued rest.* Cases occur, however, in which inflammatory changes are found in bone independently of and remotely from tubercular foci. In these cases we have to deal with a granulating osteomyelitis of the articular extremities, which, as a rule, starts from the inflammatory border of the synovial membrane. The amount of bone destruction in tubercular joints, aside from that brought about by the inflammation, is determined mainly by mechanical injuries, to which the joint is so often subjected. The muscular contractions which attend every inflammatory affection of joints in which the bony structures are concerned aggravate the intra-articular pressure at some points and add pressure-atrophy to the loss of substance caused by inflammation. The rim of the acetabulum often makes a furrow in the softened head of the femur, even if its cartilaginous covering has not undergone any appreciable changes. (Fig. 16, *d*.) The loss of tissue progresses more rapidly after the articular cartilage has disappeared under the increased pressure, while the inflammation penetrates deeper into the substance of the bone. In acetabular disease

of the hip-joint the pressure of the head of the femur against the upper rim not infrequently causes such an extensive destruction that the acetabulum becomes first greatly elongated, allowing the head of the femur to wander in an upward and backward direction until a pathological dislocation is effected. In other instances the limb is gradually shortened an inch or more, but dislocation is prevented by the formation of osteophytes above the rim of the acetabulum, brought about by a plastic periostitis in that locality. Specimens of this kind present stalactitic spurs of bone, which embrace and support the head of the femur in its abnormal locality. These destructive changes are hastened by suppuration; in fact, the suppuration transforms the softened fungous surfaces of the articular ends of the bones into ulcerating surfaces. In advanced cases of primary synovial tuberculosis both articular surfaces, as a rule, become affected as soon as the articular cartilages have been removed by the disease. The absorption of bone and molecular necrosis in this condition was formerly known and described as caries, but is now known as fungous or tubercular osteomyelitis. If caseation and the formation of a tubercular abscess do not take place a spontaneous cure is still possible, but will always result in bony ankylosis, with impairment of function of the limb. In tubercular spondylitis further extensive bone destruction is caused by the weight of the body above the seat of the disease, resulting in pressure-atrophy, and it is owing to this factor that the bodies of the affected vertebræ become wedge-shaped, the apex of the wedge being directed forward, which, if two or more vertebræ are affected in a similar manner, gives rise to the characteristic posterior curvature. In central tubercular osteomyelitis of the long bones of the hand and foot the tubercular product causes rarefaction and distension of the shaft, which gives rise to the spindle-shaped enlargement familiarly known as *spina ventosa*. If the disease does not come to a stand-still spontaneously, or, by appropriate treatment, perforation of the bone finally takes place, usually about the centre

of the swelling, which is followed by tubercular periostitis and the formation of a paraperiosteal abscess.

Para-articular Tubercular Abscess.—Tubercular abscesses in the immediate vicinity of the joint rarely form independently of an articular or osseous tubercular focus.

Bidder ("Beobachtungen über parasynoviale Scrophulöse Abscesse am Kniegelenk." *Deutsche Zeitschrift f. Chirurgie*, B. xvi) reports two cases of parasynovial or peri-articular abscess of the knee in which an affection of the joint could be positively excluded. Such cases are exceedingly rare. The diagnosis must be based upon the absence of effusion in the joint; the articular ends of the bones show no points of tenderness on pressure, and the movements of the joint are not much impaired. Such abscesses may implicate the joint secondarily by the extension of the tubercular process through the capsule to the synovial membrane. Bidder reports a case where he had reason to believe that this occurred. So constantly is a primary tubercular affection of the joint or bone associated with para-articular abscess that from the presence of the latter the existence of one or both conditions may be safely assumed. In tubercular empyema of joints, perforation of the capsule leads speedily to the formation of an abscess outside of the joint, which at once changes some of the clinical aspects of the case. The swelling of the joint is diminished, while a new swelling appears at the seat of perforation with all the characters of a cold abscess. If pain was a well-marked feature before rupture of the capsule occurred, this is relieved by the accident, on account of the sudden diminution of the intra-articular pressure. In some cases an intra-osseous focus first involves the adjacent joint, after which the process extends from here to the para-articular tissues; in other instances the para-articular affection depends exclusively on a primary synovial tuberculosis, while in a third class the communication with a primary osseous focus may be direct without involvement of a joint. (Fig. 21.) Under favorable circumstances, the communication between a para-

articular abscess and a tubercular joint may become obliterated and a spontaneous cure may follow. During an operation for para-articular abscess, it is often very difficult to find and follow the communicating tract leading to the joint or bone; usually, however, the tubercular path can be recognized and made accessible to radical treatment. After the tubercular process has extended from the bone to the periosteum, or from the joint beyond the limits of the capsule, it spreads along the connective-tissue spaces between muscles, and along tendons, vessels, nerves, and finally reaches the skin, in which a circular defect is produced, through which the contents of the abscess escape. The opening thus formed shows no tendency to heal, and soon becomes lined with fungous granulations. As this external opening is usually some distance from the primary disease, and the early location of the para-articular abscess is often difficult and sometimes impossible, it is not easy to follow the fistulous tract with a probe into the interior of the abscess and to locate accurately the primary seat of the disease.

CHAPTER XVI.

Etiology.

A GREAT deal that has been said in reference to the causation of bone tuberculosis applies with equal force to the elucidation of the etiology of tubercular inflammation of joints. I will discuss here mainly the hereditary origin of the affection. All of the old and most of the modern authors recognize heredity as one of the most frequent and potent causes in the production of tubercular disease of joints. Bryan Crowthers ("Practical Observations on the Diseases of the Joints, commonly called White Swellings," etc. London, 1808), in the introduction to his interesting book, expresses himself as follows, in support of hereditary influences in the causation of white swellings: "I shall forbear to inquire whether scrofula ought strictly to be called a hereditary disease or not; of the following facts, however, I am quite certain, that most of the patients whom I have seen afflicted with white swelling were of a strumous habit, and were descended from parents of a similar constitution. Many members of such families have been destroyed by pulmonary consumption; and, if one parent be healthy and the other of a scrofulous habit, one child produced by such union shall escape free, while the remainder are miserably attacked with the complaint, and the children will bear a strong resemblance in features to that parent whom they resemble in constitution."

Dollinger (*Wiener Med. Wochenschrift*, April 27, 1889), from a careful investigation into the antecedents of twenty-five cases of tuberculosis of bone, found that in more than one-third of them one or more of the immediate ancestors had suffered from pulmonary phthisis; so that he has come to the conclusion that the influence of the tubercular virus must be exerted through several generations before the normal resistance of the osseous structures is so far weakened that they become a suitable

soil for the arrest and development of the tubercle bacillus; in other words, that in hereditary tuberculosis the lungs are attacked in the first, the bones and joints in the second generation. Of five hundred and ninety-six cases of hip-joint disease analyzed by Gibney ("The Hip and its Diseases," p. 220. New York, 1884) with reference to hereditary and six hundred and fourteen with reference to an acquired diathesis, he succeeded in finding only one case of which it could be surely said there was no struma complicating. He states, further, that he believes that a *slight* injury often develops or acts as exciting cause, but never induces the disease unless a *predisposing cause* be present. It is difficult to understand what writers and teachers in the past, and many of them at the present time, mean when they speak of such predisposing hereditary causes. Some of them assume that it consists in a peculiar vulnerability of the tissues transmitted from parent to child. The modern views of this subject may be narrowed down to two suppositions: 1. Transmission, from parents to child, of a predisposition to tubercular disease. 2. Transmission, from parents to fœtus, of the essential microbic cause,—the bacillus of tuberculosis. The supposed hereditary predisposition is interpreted as meaning anatomical or physiological defects in the tissues, which render the organism susceptible to the action of subsequent specific microbic causes. The existence of minute anatomical defects of blood-vessels, lymphatic glands and vessels, connective-tissue spaces, etc., are looked upon as conditions which favor localization of floating microbes, which find their way into the body during post-natal life. An inherited defective vital resistance on the part of the tissues to the action of pathogenic bacteria is also considered by many in the light of an hereditary influence in the causation of disease. These conditions are recognized as hereditary influences in the causation of tuberculosis, but no satisfactory, demonstrative, or experimental proofs of their existence have been furnished; and yet, the immunity of some animals and persons to certain diseases cannot be

explained in any other way than in attributing it to some anatomical, physiological, or chemical properties of the tissues, which protect the organism against the action of certain micro-organisms which, in other animals not so protected, produce tuberculosis.

Clinical experience has also shown that a great difference is found among different persons in reference to susceptibility to the same form of infection. In many persons, for instance, inoculation with a pure culture of tubercle bacilli would be a perfectly harmless procedure; in others it would produce a local, latent tuberculosis; while, in a few, rendered more susceptible to this form of infection by antecedent hereditary or acquired causes, the inoculation of the same number of bacilli would be followed by rapid and extensive destruction of tissue, and death from early and diffuse dissemination. If their existence has not been demonstrated by clinical observation and experimental research, we are, nevertheless, forced to recognize the influence of certain as yet unknown conditions and influences inherent in the tissues, and often traceable to an hereditary cause, which favor or resist the action of the tubercle bacillus. During the last few years great progress has been made in showing that hereditary disease, in many instances, at least, is due to a more direct cause,—the transmission from parent to fœtus of the essential microbic cause of tuberculosis. This method of infection is not only interesting from a scientific stand-point, but is of the greatest practical importance, alike to the surgeon and physician, in regard to prophylaxis, diagnosis, and treatment of tuberculosis. Although our knowledge of the intra-uterine origin of tuberculosis is yet imperfect and fragmentary, there can be no doubt that future study and research will clear up many existing dark points, and furnish a satisfactory demonstrative explanation of the direct and indirect transmission of the bacillus of tuberculosis in the causation of this disease. One of the first positive demonstrations of direct transmission of tuberculosis from parent to offspring was furnished by

Curt Jani (London *Lancet*, September 4, 1886, p. 455). He examined the healthy sexual organs of nine male phthisical patients for tubercle bacilli. No bacilli were found in any of these in the semen from the vesiculæ seminales; but, on the other hand, in five out of eight cases a few were found in the testicle, and in four out of six in the prostate. The testicles and prostate appeared healthy in structure. He, further, examined two women who died of pulmonary phthisis, the ovaries in both presenting negative results. In one case of chronic pulmonary phthisis, with extensive intestinal tuberculosis, he examined the Fallopian tubes and found tubercle bacilli. He is of the opinion that bacilli can be transmitted from parents to fœtus in one of two ways: (1) through the semen of the male; (2) through the migration of bacilli into the uterus from the Fallopian tubes. Infection of the impregnated ovum by the placental circulation, he thinks, must be unusual, because the examination of the body of a woman, five months pregnant, who died from acute miliary tuberculosis, in whom infection took place through the growth of a caseous mass in the pulmonary vein, showed that there were no bacilli, either in the placental attachment, in the lungs, or in any of the organs usually the seat of localization in the embryo. He, however, considers that it is by no means certain that, in chronic miliary tuberculosis, deposits may not form in the neighborhood of the placenta, and thus infect the fœtus. Tuberculosis of the genital organs of the female has been described by Zweigbaum (*Centralblatt f. Bacteriologie u. Parasitenkunde*, B. xi, p. 558), Barbier (*Gaz. Médicale*, No. 39, 1888), Kotschau (*Archiv f. Gynækologie*, B. xxxi, Heft 2), Werth (*ibid.*, July 20, 1889), Jonin (*Bulletin Paris Obstet. and Gynæcological Society*, March, 1889), and others. Tubercular affections of the organs of reproduction of the male have been studied by Dahnar, Kraske, Albers, Jaye, Naumann, Humphrey, Kocher, Rayer, Cruveilhier, Reclus, Ullman, and Strümpell. Jani found typical tubercular products in the fœtus of a cow that died of tuberculosis.

Charrin ("Tuberculose Généralisée chez un fœtus de sept mois et demi." *Lyon Médicale*, No. 14, 1873) describes a case where a woman, 29 years of age, without a hereditary history of tuberculosis in her family, suffered from pleuritis during the fourth month of pregnancy, which was followed by a cheesy pneumonia. She was delivered of a fœtus seven and one-half months old, which died on the third day. The post-mortem examination of the fœtus revealed tuberculosis of the liver, spleen, and mesenteric glands. The mother died soon after the delivery, and the autopsy showed advanced pulmonary tuberculosis.

Birch-Hirschfeld (*Wiener Med. Blätter*, No. 17, 1891) relates a case in which a fœtus was removed from the uterus of a woman, aged 23, within a few moments of her death from general tuberculosis, without any damage being done to the placenta. Portions of the liver, spleen, and kidneys of the fœtus produced tuberculosis when inoculated into rabbits and guinea-pigs, but only in the capillaries of the liver could tubercle bacilli be discovered. In the placenta, however, the villous spaces were crowded with bacilli. *The very meagre evidences of bacilli in the fœtus might serve as an explanation of the fact that children of tubercular parents are often born without any manifestation of tubercular disease, and yet appear to develop tubercle during the first few years of life. A limited infection by maternal bacilli, perhaps during the progress of birth, might remain latent in one or more organs until other circumstances contribute to their development. It is thus possible that confusion may exist between "latent tuberculosis" and "tubercular predisposition."*

I am firmly convinced that direct infection from parent to child occurs more frequently than is generally supposed, and that many of the later manifestations of tuberculosis are attributable to this source. Floating bacilli in the blood of infants may do no harm until a *locus minoris resistentiæ* is created by a slight injury or by acquired pathological conditions after birth. Post-natal infection through abrasions of the skin or exposed

mucous surfaces in children coming in contact with tubercular patients is also a frequent source of tubercular disease of bones and joints. *It is not necessary or essential, in such cases, that a tubercular lesion should be produced at the point of invasion, as the bacilli may reach the general circulation through the infection-atrium without causing a surface lesion, and become, later, localized in a joint predisposed to tuberculosis by congenital defects or accidental pathological conditions.* We have every reason to believe that in many instances the tubercle bacilli enter the organism through the respiratory tract and produce tubercular arthritis in joints which have been rendered susceptible to this affection by injury, or antecedent or coincident disease. In children, infection is often traceable to ingestion of milk contaminated by tubercle bacilli, and in such cases localization in joints takes place in the same manner as when the essential cause gains entrance through the skin or the respiratory organs. The influence of trauma in the production of joint tuberculosis is the same as in the causation of the same disease in bone. Here, as in bone, a severe injury is seldom followed by tuberculosis, as the injuries to which the causation of this disease are usually attributed are slight, and are often forgotten before the first symptoms show themselves. Injury can only produce tubercular osteomyelitis or arthritis in patients already infected with the essential cause, and must be regarded *only in the light of an exciting cause. It must be assumed that after a severe trauma the energy of the reactive and reparative tissue-proliferation is so considerable as not to permit the development of the tubercle bacilli,—a hypothesis for the admissibility of which the behavior of the lower organisms offers numerous analogies. On the other hand, it would appear that slight injuries, combined, perhaps, with extravasation into the cancellous tissue of bone, slight synovial exudation, and, in any case, certain changes in the nutritive conditions of the affected tissues, furnish a favorable soil for the development of the tubercle bacilli.*

Age is an important factor in the causation of tubercular affections of joints. These affections manifest a strong predilection for persons under the age of puberty. Barwell ("On Certain Points in the Etiology of Hip-Joint Disease." London *Lancet*, August 2, 1879) makes the assertion that he never met with a case of hip-joint disease that commenced in a patient more than 25 years of age. Only one case came under his observation where the patient was 18 years of age; and the majority of patients were less than 12 years old. He is of the opinion that the most important predisposing cause is the great vascularity which is present in the vicinity of bone-producing cartilage in young persons. Barwell's views in regard to the importance of age as an etiological factor in the causation of joint tuberculosis are somewhat extreme, as I have repeatedly had patients under my care in whom the disease commenced after 40 years of age. The wrist- and knee- joints are quite frequently the seat of tuberculosis in persons advanced in years, and even old age is not quite exempt. It is quite often the case that children who suffer an attack of tuberculosis of the lymphatic glands or skin become later the victims of a joint tuberculosis. Volkmann (*Centralblatt f. Chirurgie*, No. 24, 1885) has well said: "A person suffers from tuberculosis of the lymphatic glands in youth, has a tumor albus or arthrocace toward puberty, and dies from pulmonary tuberculosis in the thirties. This is very common and cannot appear astonishing, since the susceptibility to the said virus is not lessened by having withstood a tubercular infection. The persons in question possess, at least in the great majority of cases, an individually-increased susceptibility to the virus, and this is about them everywhere."

Among the exciting causes must be mentioned the acute infectious diseases. About fifteen years ago Luecke called attention to the etiological relationship which exists between acute infectious diseases and tuberculosis of joints. Keen (*Transactions of the American Orthopædic Association*, vol. ii.

"Typhoid Spine," by V. P. Gibney) has given a good account of all bone-lesions following the continued fevers. He found 69 cases, of which 22 affected the head, 7 the trunk, 6 the upper and 42 the lower extremities. In 37 cases the disease followed typhoid fever. As to the date of the occurrence, in 47 cases, 10 were within two weeks, 27 from three to six weeks, and 10 some months after the fever. Keen's explanation was that the earlier cases probably resulted from thrombosis, and the latter from enfeebled nutrition. Trauma, if any, in these cases was always slight. These cases include all pathological forms of bone and joint disease, but among them not an inconsiderable number were tubercular in their character. Sudden exposure to cold is another etiological element which should not be ignored. Sudden suppression of cutaneous perspiration, combined with diminution of the peripheral circulation, often brings about the necessary local conditions of the deep-seated vessels, which determine localization of bacilli from the blood in the articular extremities of the long bones and the soft structures of joints,—an occurrence which, without such influences, might have postponed indefinitely the localization, or disease might have been entirely avoided. Rheumatism also appears to act as one of the predisposing causes to tubercular synovitis. At the Rouen Congress, in 1883, Verneuil hinted at the possible combination of the tubercular and rheumatic diathesis as mutual etiological factors. October, 1886, Peyrot and Jonnesco presented to the second French Surgical Congress a case of tubercular panaris in an adult, invading a nodosity, on a finger, left by rheumatism. In July, 1888, Jonnesco furnished another observation of tubercular arthritis in a rheumatic, who, in his infancy, had presented various enlarged cervical glands, then passed through an attack of acute articular rheumatism, and finally suffered from a tubercular arthritis of the right knee-joint, followed by a similar attack of the left knee-joint. His father died of tubercular enteritis at the age of 40, and his mother, aged 68 years, was a confirmed rheumatic

invalid. *In brief, the etiology of tuberculosis of joints may be summarized to the effect that the essential cause consists in the presence of tubercle bacilli, in sufficient number, in the soft structures of the joint, to enable them to exercise their specific pathogenic properties upon tissues predisposed to infection by hereditary or acquired causes.*

CHAPTER XVII.

Symptoms and Diagnosis.

The clinical study of joint tuberculosis should precede the subject of bone tuberculosis, although the etiological relation of the latter to the former has already been discussed. Most forms of osseous tuberculosis give rise to a complexus of symptoms characteristic of joint tuberculosis. The symptoms vary, according to the type of the disease and manner of infection. In all varieties the symptoms and clinical picture point to the existence of a chronic inflammation. With the exception of circumscribed points of tenderness outside of the joint, that indicate the existence of primary osteotuberculosis during its early stage, we have no symptoms which enable us to make a positive differential diagnosis between a primary osseous and a primary synovial tuberculosis of a joint. The primary osseous form is the most common. In the knee the proportion of the primary osseous to the primary synovial form is as the proportion of 3 to 1; in the hip, 4 to 1; in the elbow, 4 to 1. As to age, the proportion is, in children below 15 years of age, 2 to 1; above 15, 3 to 1. In reference to the location of the joints affected, it can be said that joint tuberculosis is much more frequent in the lower than in the upper extremities. According to Albrecht, out of 325 cases, in 91 the disease affected the joints of the upper and in 234 those of the lower extremities. A tubercular arthritis presents so many characteristic clinical features that a correct diagnosis can usually be made by a careful study of symptoms.

Swelling.—This symptom is not present in all forms of synovial tuberculosis. In the atrophic form of plastic synovitis, the *caries sicca* of Volkmann, so common in the shoulder-joint, there is not only no swelling, but the region of the joint may even be found *diminished in size* from muscular atrophy. The absence of swelling and the presence of considerable mobility

in the joint may lead to a wrong diagnosis, under the impression that the affection is a neurosis. A careful examination, under the influence of an anæsthetic, will, however, reveal restriction of mobility from cicatricial contraction of the tubercular capsule, which will enable the surgeon to make an early and correct diagnosis. In the other forms of synovial tuberculosis more or less swelling is always present. The swelling is due either to effusion into the joint, thickening of the capsule, or para-articular exudation. The swelling resulting from tubercular hydrops and intra-articular abscess is caused almost exclusively by distension of the capsule with fluid, as the capsule in either case is but little thickened, and the granulations are scanty. In both of these conditions the capsule of the joint is often enormously distended. In the knee-joint the patella is raised from the condyles of the femur, and the depression on each side of it, present in a normal condition in the extended position of the limb, is not only effaced, but replaced by a well-marked prominence. Tubercular hydrops and diffuse synovial tuberculosis, with proliferating disease of the synovial membrane, are often complicated by the formation of masses of fibrin in the joint, which appear either as free bodies or adherent deposits upon the synovial membrane. In the latter case the fibrin, with the thickened synovial membrane, forms a circumscribed swelling, which sometimes can be located by external examination. In the tuberous variety of synovitis, the synovial membrane presents either firm, circumscribed swellings, if the deeper fibrous portions are affected, or numerous tubercles with a tendency to caseation. The presence of tubers or fibrinous deposits often occasions the crackling sound felt and heard on moving the joint. In the dry, fungous variety of synovitis, the swelling is due to the masses of granulation tissue within, and, after perforation of the capsule has occurred, within and outside of the joint. The uniform soft swelling is due more to the presence of fungous granulations than effusion into the joint, as the hydrops is only a secondary,

accidental condition, which, in the course of time, disappears completely.

The local symptoms are most conspicuous in diffuse synovial tuberculosis with slight swelling of the synovial membrane and capsule, when a moderate hydrops of the joint is often one of the earliest and most prominent symptoms. The tubercular nature of the primary lesion frequently becomes evinced by the quick re-appearance of the effusion after tapping. This is the most common of all the forms of articular tuberculosis. The old authors were of the opinion that the œdema in the neighborhood of a white swelling was due to expansion or enlargement of the articular extremities of the bones, until Samuel Cooper pointed out that it was caused by thickening of the capsule and infiltration of the soft tissues around the joint.

The invasion of the para-articular tissues causes considerable swelling in the region of the joint, imparting to the latter the characteristic spindle-shape so frequently found in the knee-, elbow-, and ankle- joints, the swelling being so much the more conspicuous when atrophy of the muscles above and below has taken place. Extension of the infiltration from the para-articular tissues in the direction of the subcutaneous tissues finally causes the swollen joint to be covered with a blanched, immovable, dense skin, giving the joint the appearance from which the time-honored name of *white swelling* was derived. If a para-articular abscess appear the swelling of the joint is generally diminished, while a new swelling forms in the vicinity or some distance from the joint.

Fluctuation.—In tubercular hydrops and intra-articular tubercular abscess this symptom is well marked; but fluctuation is sometimes distinctly felt, and yet when the joint is aspirated no fluid can be withdrawn. In such cases the sense of fluctuation is given by masses of soft granulations within the joint. Wiseman ("Chirurgical Treatise," p. 261) was well acquainted with the pseudo-fluctuation that is often felt when the joint is distended with fungous granulations, as appears from following passage:

"But, if through want of such treatment they (joints) grow excessively swelled, and the tumor incapable of being pressed back or discussed, you may shrewdly expect the bones corroded; for, that swelling is for the most part raised by an hypersarcosis within, and ought not to be opened without a prediction of a caries, for, however it may, by a *seeming fluctuation* (Italics my own), be thought to have matter, yet, upon opening, it will only discharge a gleet, and the hypersarcosis will thrust out into a fungus."

The difference between the swelling of a joint caused by inflammatory material and effusion and the physical symptoms resulting from it were clearly pointed out by Simon Pallas ("Practische Anleitung die Knochen-Krankheiten zu heilen," p. 204. *Berlin u. Stralsund*, 1770), one of the surgeons to the Charity Hospital in Berlin, as early as 1770, in the following language: "Es Können aber auch allerhand Geschwülste derer Gelenke eine Steifigkeit solcher Gelenke herfürbringen, dergleichen sind 1 der Gliedschwamm (fungus articulorum); solcher bestehet in eine unschmerzhafte, blasse Geschwulst derer Gelenke, welche zwar nachgiebt wenn man mit den Fingern darauf drücket, Jedoch sich gleich wiederum erhebet, sobald man die Finger weg thut. Es unterscheiden sich diese Geschwülste von der Wassersucht der Gelenke, darinnen, dass erstere mit rund herum das Gelenk einnehmen, wie letztere, und dass bei der Wasser ansammlung, die Feuchtigkeiten in das Gelenk selbst angehäuft sind." The granulation tissue is often present in such abundance as to give rise to considerable distension of the joint, and, in the knee-joint, elevating the patella from the condyles of the femur to such an extent that the contour of the joint simulates, almost to perfection, an effusion into the articulation. The granulations are so soft that on palpation a sense of fluctuation can be distinctly felt, especially if the capsule of the joint is very thin from overdistension or destructive changes. Fortunately, we are now in possession of a diagnostic resource which will enable us to make a positive differential diagnosis

between an effusion in a joint and granulating synovitis, and this is the employment of the exploring syringe. If any question remain as to the intra-articular conditions when fluctuation can be elicited on palpating a diseased joint, this instrument should be called into requisition and the joint explored under strictest antiseptic precautions.

Muscular Contraction.—Contraction of the flexor muscles of a diseased joint is often one of the earliest conditions which are produced by tubercular arthritis, but in tubercular hydrops this symptom is always absent. In chronic inflammation of joints the explanation of Bonnet, that contractions are caused by intra-articular pressure, is no longer tenable, as Luecke (*Deutsche Zeitschrift f. Chirurgie*, B. xxi, Heft 5) has shown conclusively that in fungous disease of joints the flexed position is induced by the irritation due to inflammation, as in that posture the least amount of pain is incurred; if the patient now attempt to walk he naturally contracts all the muscles, so as to avoid any movement which would aggravate the pain. This contracted state of the muscles, however, tends still to heighten the degree of flexion, as the flexors are naturally and anatomically stronger and less easily fatigued than the extensors. Therefore, the longer this flexed position has been maintained, the more marked it becomes, as is the case in paralysis originating in the nervous centres. Luecke is of the opinion that, in chronic joint disease, the flexed position of the joint is adopted voluntarily or from expediency, so as to facilitate the use of the limb, in the same manner as scolio-lordosis is adopted to compensate adduction, disappearing when the patient is confined to bed, as its only purpose is to avoid limping. The posture is further influenced by the destruction of integral parts of the joints; adduction in the hip, for instance, is caused by destruction of the acetabulum, in the same manner as the varus position of the knee is due to destructive changes affecting the internal condyle of the femur or the inner tuberosity of the tibia.

Remak ("Contractur bei Tuberkulose." *Berliner klin.*

Wochenschrift, B. xxvii, No. 15, 1890) is of the opinion that contraction of muscles in tuberculosis of joints is the consequence of a reflex neurosis. He cites, in illustration of the correctness of his position, a case of tuberculosis of the shoulder-joint in which he found the tendon-reflex of most of the muscles of the shoulder and arm greatly increased, but not so the mechanical irritability.

FIG. 29.—EARLY STAGE OF COXITIS—SLIGHT FLEXION OF THIGH AND ROTATION OF LIMB OUTWARD. (*Sayre.*)

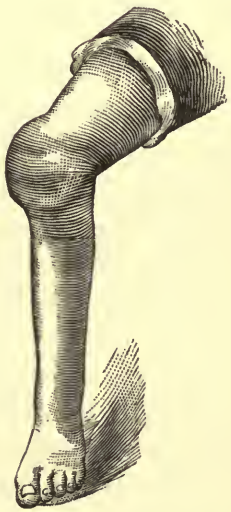

FIG. 30.—TYPICAL APPEARANCE OF KNEE-JOINT, CAUSED BY LONG-STANDING TUBERCULAR DISEASE OF THE JOINT. (*Sayre.*)

There can be but little doubt that this factor plays an important part in the production of muscular contractions during the early stages of joint disease, and that the structural changes in the joint which occur later, and which determine fixation of the joint in malposition, are due, at least in part, to the increased intra-articular pressure and destruction of tissue resulting from the prolonged muscular contractions and the inflammatory process.

Shortening of Limb.—The impression has prevailed for a long time that the shortening of a limb affected by tubercular joint disease is caused almost exclusively by destructive changes in the articular extremities, but Julius Wolff ("Ueber trophische Störungen bei primären Gelenkleiden." *Berliner klin. Wochenschrift*, Nos. 28, 29, 30, 1887) has shown that the extent of loss of substance does not always determine the degree of shortening. He has made the observation that, in some instances, the affected limb is actually elongated. He attributes the shortening largely to a tropho-neurotic affection in connection with joint disease, which brings about a diminution in thickness and length of the bones of the affected limb. The same view is entertained by Valtat and Remak. Analogous conditions of the bones are met with in infantile paralysis and progressive muscular atrophy (Friedreich, Volkmann). Whether the atrophy of the bones is due to a secondary neuritis or follows in consequence of a reflex action of the trophic centres in the spinal cord Wolff is unable to decide, but is inclined to support the latter theory, which is the one so generally supported by French authors.

Dislocation and Other Deformities of Joint.—Contraction, rotation, lateral deviations, subluxations, and other abnormal positions usually indicate more or less destruction of the articular surfaces of the bones and structural changes of the ligaments. These malpositions are not seen in articular hydrops or the milder forms of synovial tuberculosis, while we find different degrees of one or more of them in nearly every case of advanced fungous synovitis. In advanced cases of synovial tuberculosis of the knee-joint the joint is flexed, the leg rotated outward, and the head of the tibia displaced backward. In the hip-joint the disease gives rise to flexion of the thigh upon the pelvis, and at first eversion but later inversion of the limb. After separation of the head of the femur, or extensive destruction of the articular end of this bone and the acetabulum, the contour of the region of the hip-joint and the position of the limb simulate dislocation

of the head of the femur upon the dorsum of the ilium or fracture through the neck of this bone. Tubercular disease of the elbow-joint gives rise to flexion and pronation of the forearm. The clinical importance of any of these displacements lies in the fact that they signify a certain amount of destruction of the joint structures, thus often indicating surgical interference for the correction of the deformity, as well as the removal of the diseased tissue. Complete and partial dislocations, occurring in consequence of tubercular arthritis, have given rise to a great deal of discussion in regard to the nature of the pathological conditions which produce them and the extent of the displacement. Sonnenburg ("Die spontanen Luxationen des Kniegelenks." *Deutsche Zeitschrift f. Chirurgie*, B. xli) has found that in some cases of apparent dislocation of the tibia backward, in chronic inflammation of the knee-joint, there is no displacement of the articular surfaces, but the deformity is caused by a bending of the tibia at the upper epiphysial line, which gives rise to an appearance of the joint which closely resembles a partial dislocation of the head of the tibia backward. In adults the same condition can follow osteoporosis of the upper end of the tibia. This deformity is prone to occur in persons confined to bed for a long time with disease of the knee-joint; when the leg is so placed that it rests its weight at a point some distance below the knee-joint this support acts as a fulcrum and transforms the tibia into a lever. In persons who use the limb this partial infraction may occur in consequence of the peculiar manner in which the patient rests the weight of the body on the diseased limb in walking. Usually, however, the deformity which attends fungous synovitis is caused either by muscular contraction, faulty position of the limb, or destruction of the soft and bony structures of the joint, or follows the effect of the action of two or all of these causes combined.

Pain.—Pain, as a symptom accompanying tuberculosis of joints, although always present, is of extremely variable intensity. If the diseased part is in such a location that it is pro-

tected from injury, and perfect rest can be secured, it is so slight that this symptom is often overlooked by patients, even in cases where the disease has arrived at an advanced stage. In some cases of primary synovial tuberculosis it is so slight that patients will continue to use joints distended with masses of fungous granulations without much suffering, while in other instances a limited disease in the joint will cause complete disability and a great deal of suffering. According to my observation, the pain is usually more severe in cases where the granulations are scanty than when the synovial membrane is the seat of extensive fungosities. As a point in differential diagnosis, it may be said that, in osseous tuberculosis, pain is present from the beginning in the bone, and is not much aggravated if the primary disease in the bone is followed by a secondary affection of the adjacent joint; while an almost painless primary synovial tuberculosis is followed by severe pain, with nocturnal exacerbations, as soon as the synovial membrane and articular cartilages have been destroyed and the bone has been secondarily implicated in the inflammatory process. Absence of tenderness away from the joint would indicate rather a primary synovial tuberculosis than the osseous variety. In primary synovial tuberculosis of the hip-joint the pain is located in the joint and groin; while in the osseous form, during the early stage, at least, it is usually referred to the inner aspect of the knee.

Differential Diagnosis.—Remembering the frequency of tuberculosis of joints as compared with affections due to other causes, as a rule, there is little difficulty in their recognition if the history, course, and symptoms are carefully studied and analyzed. König justly remarks that it is well to remember that articular tuberculosis, even if the disease affect a large joint, is practically a local disease, and has for a long time little or no influence on the general health of the patient. Thus, we may find patients presenting all the appearances of robust health suffering from extensive articular tuberculosis.

The tubercular hydrops is distinguished from a catarrhal or rheumatic synovitis with copious effusion by its persistency and tendency to return after aspiration or after active use of the joint. The presence of flocculi or rice-bodies in a joint confirms the tubercular nature of the affection. A tuberous synovitis, with the formation of a single mass of tubercular tissue, sessile or pedunculated, might be mistaken for lipoma arborescens or gummata. The diagnosis of the latter will be cleared up by a course of antisyphilitic treatment, which should always be instituted in cases of doubt. Tubercular joint-abscess is distinguished from suppurative, gonorrhœal, or rheumatic synovitis by the pain being less and the absence of all signs of acute inflammation. The local conditions in fungous synovitis are so characteristic that they can hardly be misinterpreted by a careful observer. The presence or absence of fluid in the joint has often to be determined by an exploratory puncture. The *caries sicca* of Volkmann, or dry, pannous, hyperplastic synovitis of Hueter, especially as found in the shoulder-joint, might be mistaken for a neurosis, with atrophy of the muscles covering the joint. The differential diagnosis can be made by examining the patient when fully under the influence of an anæsthetic. If the affection is a neurosis, motion will be found unimpaired; if it is tubercular, the mobility of the joint will be found lessened by intra-articular adhesions and cicatricial contraction of the capsule of the joint. It is necessary under this heading to discuss somewhat more fully the important points in differential diagnosis of a few affections of the joints which are most likely to be mistaken for tuberculosis, and *vice versâ*.

Rheumatic Arthritis.—Acute rheumatism appears clinically as a poly-articular affection. The essential cause of this disease very frequently attacks at the same time the heart-muscle and the endocardium and pericardium. It is a febrile affection, and often disappears after a few weeks without medical interference. Subacute rheumatic arthritis involves the synovial membrane, capsule of joint, and para-articular fibrous structures; the in-

flammatory product consists of a plastic exudation, the removal of which proves exceedingly obstinate to all known methods of treatment. In the chronic variety the disease may be limited to a single joint; but more frequently a number of joints are affected simultaneously or in succession. This disease resembles tubercular arthritis more closely than the acute and subacute varieties, in that it attacks not only the synovial membrane and capsule of the joint, but not infrequently extends to the articular extremities of the bones, giving rise to a complexus of symptoms which closely resembles *caries sicca.*

Syphilitic Arthritis.—In syphilitic joint affections occurring as one of the manifestations of the subacute form of syphilis during the second stage, the synovial membrane, para-articular tissues, or periosteum are affected. In the tertiary form of the disease gummata develop in the subsynovial tissues or periosteum. The syphilitic joint affections, during the second stage, are different from the rheumatic, in so far that the fever attending the former shows marked paroxysmal exacerbations toward evening; at the same time involvement of the lymphatic glands and other luetic symptoms are present. In the tertiary form the joint and bone affections have the peculiarity that the affections develop slowly, and the separate gummata appear as circumscribed indurations. If any doubt remain as to the nature of the joint affection between syphilis and tuberculosis, this can be readily dispelled in a few weeks by placing the patient under an energetic antisyphilitic treatment. Gillette ("Diseases of the Hip-Joint." *Medical News*, July 11, 1891) relates a very interesting case of syphilitic coxitis in a child 7 years old. There was apparent lengthening, but actual shortening; atrophy of limb, but only slight tenderness; limb abducted and slightly flexed. The mother gave a history of the patient having had a similar attack four years previously. At that time the joint was very painful, and was treated by immobilization in a plaster-of-Paris dressing. As the child presented a suspicious eruption, antisyphilitic treatment was instituted,

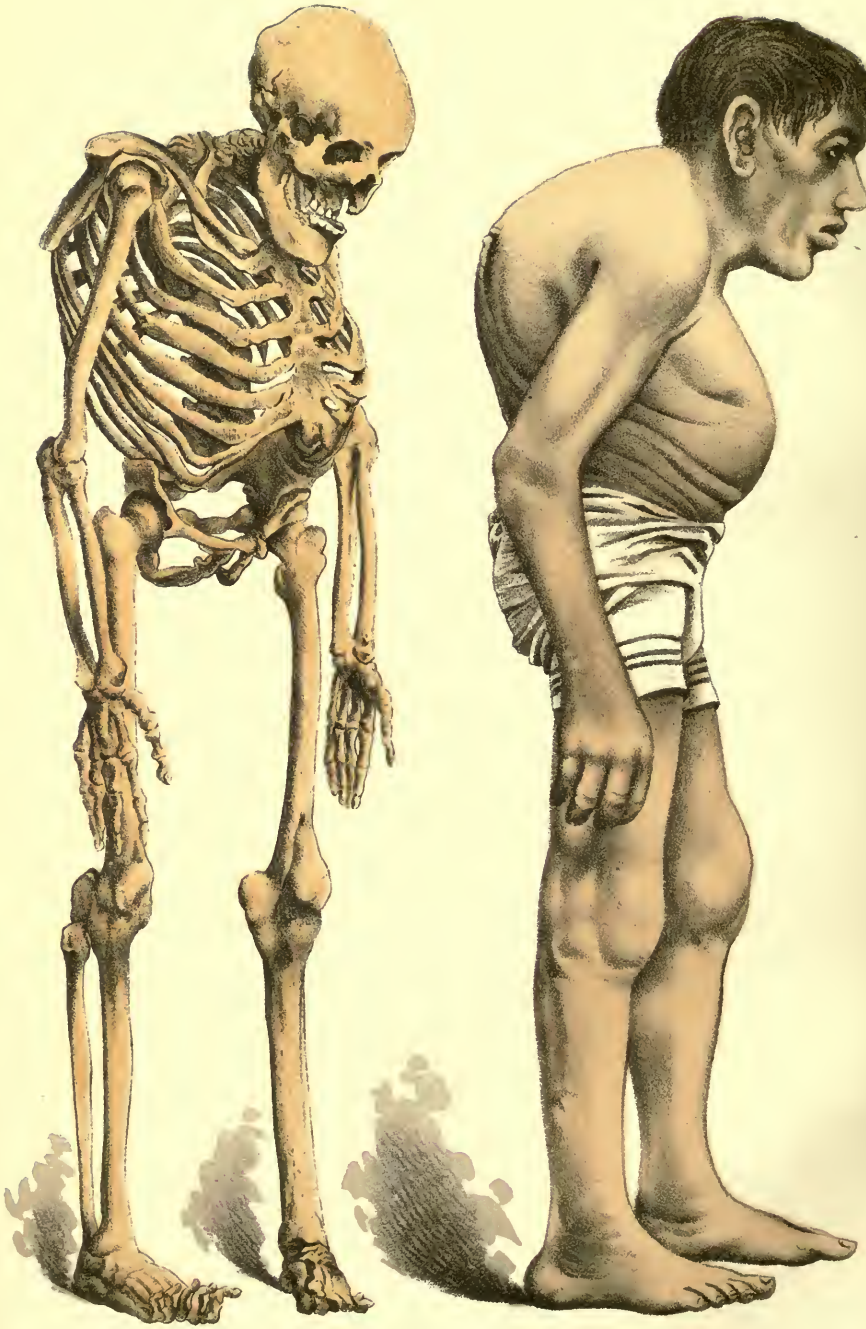

FIG. 31.—ACROMEGALIA (?). OSTEITIS DEFORMANS. (Marie.)

which resulted in a complete recovery. The second attack resembled a typical tubercular coxitis. The usual treatment by rest in bed and extension proved of no avail. A well-marked syphilitic eruption again suggested a syphilitic cause, and a short course of specific treatment resulted again in a speedy and perfect cure.

Osteitis Deformans.—Osteitis deformans, as it usually presents itself, is recognized without much difficulty, and is not likely to be mistaken for joint or bone tuberculosis. When the disease affects the spine, the kyphosis resembles the curvature in cases of tubercular spondylitis when a number of vertebræ are affected at the same time. Marie describes such a case as acromegalia; but Virchow regarded it as a case of osteitis deformans. (Plate VI, Fig. 31.)

Typhoid Arthritis.—A number of acute infectious diseases —notably typhoid fever—are followed, within a few days to several weeks after convalescence has been apparently established, by a non-suppurative destructive joint affection, which, in many respects, resembles tubercular arthritis, and which it is often very difficult to distinguish from the latter affection.

Gibney (*Transactions American Orthopædic Association*, vol. ii), in an article on "Typhoid Spine," reports cases of disease of the hip-joint which bear a close resemblance to tuberculosis of this joint. One was that of a young lady, 18 years old, convalescing from typho-malarial fever and suffering with acute pain in the hip. Any movement of the limb would excite severe pain. Extension afforded relief in less than a month. Almost complete recovery followed in a few months. Gibney regarded this case, from a pathological stand-point, as a para-articular lesion confined to the periosteum or ligaments. Another case was that of a boy aged 13. Four or five months after an attack of typhoid fever, while confined to his bed, he kept both limbs flexed, and during convalescence was unable to straighten them. The thighs were sharply flexed on the pelvis, the legs on the thighs, the heels touching the

buttocks. Any attempt at motion of the right thigh caused reflex spasm.

Sarcoma of Joints.—This affection is exceedingly rare, and on this account it would most likely be mistaken for tuberculosis unless special attention were given to differential diagnosis between these two affections. Garrè reports an interesting and rare case of diffuse sarcoma of the synovial membrane and ligamentous structures of the knee-joint. (*Beiträge zur klinischen Chirurgie*, B. vii, Heft 1.) A woman, aged 34, died one month after amputation through the thigh, and, on post-mortem examination, large and widely-diffused secondary deposits were found in almost every organ of the body. The diagnosis of the nature of the disease in this case was at first attended with some doubt, as the swollen and pulpy condition of the affected joint suggested tuberculosis. Microscopical examination after amputation showed it to be a diffused, round-celled sarcoma of the capsule of the knee-joint, with medullary sarcoma of the lower end of the femur. The author is of the opinion that the tumor started primarily in the soft structures of the joint, and not in the bone. The soft structures of the joint had been converted into a mass of very thick and firm tissue, and the disease had been so much diffused as to surround and compress the popliteal vessels. Before the amputation the temperature taken in the rectum had been irregular and at times high. According to Garrè, inexplicable elevations of temperature at irregular intervals frequently occur in cases of sarcoma of bone. The constitutional disturbances were, it is stated, much more intense in this case than those usually present in cases of localized tubercular lesion.

Popliteal Cysts.—In the differential diagnosis between chronic affections of the knee-joint and its immediate vicinity, it is necessary to call special attention to the subject of popliteal cysts. After post-mortem examination of over a thousand knee-joints, and after clinical observations of upward of a hundred patients suffering from cysts about the knee, Poirier (*Le Progrès Médical*, vol. xii, No. 43) came to the conclusion that pop-

liteal cysts, even those which occupy the portion of the bursæ, are nearly all of articular origin. Of one hundred cases subjected to most rigid examination, not one was found which had not a distinct articular origin. The most frequent variety of popliteal cysts is that which is found external to the tendon of the semimembranosus in the popliteal flexure. It is very prominent when the leg is extended, but seems to disappear on flexion. It implicates the bursa placed between the tendon of this muscle and the internal condyle. This bursa is, however, in closer relation to the cavity of the joint than any of the other bursæ, and often communicates with it directly. Another form of cyst, not so frequently recognized, is that due to the outgrowth of the synovial membrane of the joint. It involves the bursa beneath the popliteus, and appears as a deep-seated swelling in the upper portion of the calf. A third variety of popliteal cysts is that which appears in the upper portion of the condyloid region. The bursa placed above the internal condyle is usually a prolongation of the synovial lining of the joint. Finally, cysts may appear in any part of the joint, presenting the features of ganglion, but really due to the development of subsynovial cysts or to synovial hernia.

Echinococcus.—As an extremely rare chronic joint affection, which might be confused with tuberculosis, must be mentioned echinococcus. Fischer (*Deutsche Zeitschrift f. Chirurgie*, 1891, Nos. 1 and 2) has reported the case of a man 44 years old, in which, following an injury of the lower end of the left thigh, great pain, swelling, and fluctuation appeared at the knee-joint. An incision above and internal to the patella evacuated a considerable quantity of a thin, nearly clear fluid, with about a dozen echinococcus cysts. Swelling and fluctuation, however, returned. The knee-joint was then exposed, and many echinococcus cysts, with serous fluid, were evacuated. The vascular synovial membrane and the suspected parts of the capsule of the joint were extirpated and the lower end of the femur thoroughly cleansed; complete recovery ensued, with scarcely any impairment of the usefulness of the joint.

CHAPTER XVIII.

Prognosis.

A person who has once been the subject of a tubercular affection of a joint is always in danger of suffering from a local recurrence or tuberculosis in some other organ. Even the most thorough operation cannot afford absolute protection against local relapse or distant tuberculosis. For many years König has taught most emphatically that a tubercular affection of bones and joints is only a peripheral manifestation of the existence of other tubercular affections, and that it is never met with etiologically as a primary lesion. If this is the case, and his position has been well supported by clinical facts, it is evident that complete local eradication of the bone or joint disease by operative measures might prove successful in preventing re-infection from the existing peripheral lesion, but all known efforts would prove futile in affecting a permanent cure, as hidden and inaccessible foci which caused the bone or joint affection may at any time become again a distributing point of the essential cause of the disease,—the bacilli of tuberculosis. In not an inconsiderable number of cases of peripheral recognizable tuberculosis, patients are already the victims of tubercular affections of one or more of the internal organs, notably the lungs. In two hundred and fifty-eight cases collected and studied by Thiéry with special reference to this point, he found in sixty-three well-marked evidences of pulmonary tuberculosis; in seventy-two no signs of pulmonary lesion, and no reference to this condition in one hundred and twenty-three.

In tuberculosis of the vertebræ the same author found one out of six cases affected at the same time with visceral tuberculosis. Aside of the constant danger, owing to the existence of additional inaccessible foci, it is impossible to foretell at what time re-infection may take place from a tubercular joint. In order to determine the time at which a local focus gives rise to

local and general infection, Jeannel ("Nouvelles recherches expérimentales sur la tuberculose et sa curabilité." *Étude sur la tuberculose*, p. 416) inoculated seventeen rabbits in the left ear with material taken from a tubercular cow. The ear of each of these animals was cut off three to four centimetres from the point of inoculation at intervals of twenty-four hours, and the specimens representing inoculations from twenty-four hours to seventeen days were carefully examined. Ten of the rabbits died of tuberculosis. The animals that lost the inoculated ear during the first four days presented well-marked tubercular lesions. In a second series of experiments conducted in the same manner, four of the rabbits were tubercular and six had escaped the disease, and in a third series all of the rabbits were found to be tubercular. From these experiments the author comes to the formidable conclusion that, after subcutaneous inoculation with tubercular material in rabbits the disease has ceased to be local in twenty-four hours, and that generalization may take place in a few hours after inoculation. In all of the animals in which the inoculated ear was amputated within ten minutes after inoculation, no local or general tuberculosis was observed, but when the time was extended beyond this the animals became tubercular. Although the results of these experiments are, of course, not applicable to man, they teach the surgeon at least an important lesson in that a local tubercular focus at any time may become the centre of a regional and general infection, and that its removal before this has occurred protects the organism against re-infection from this source. At the same time it should not be forgotten that the removal of a peripheral tubercular lesion has often a curative effect on similar internal lesions which can only be attributed to suppression of re-infection from the peripheral focus. Among the cases in which operative treatment under such circumstances gave the most happy results is one related by le Fort in his clinique, December 20, 1888. He amputated the right arm and thigh for tubercular affections in a patient who was suffer-

ing at the same time from pulmonary phthisis. The patient's general condition improved, and the bacilli in the sputum became much less in number. The improvement continued steadily for a long time, and was in progress when the report was made, when he was still an inmate at the Bicêtre. At the same time le Fort cited the history of another case, where the patient had already submitted to several amputations, and for whom he proposed to amputate the forearm for a new tumor albus. This patient was free from pulmonary tuberculosis, and recovered his usual health and weight after amputation. Post-operative results are sometimes most favorable in previously tubercular patients, instances of which are reported by Thiéry. In one case the patient was suffering from osteo-arthritis of foot; at the same time he coughed up bloody sputa. Amputation of leg; healing of wound delayed by imperfect suturing; general health improved promptly. In another somewhat similar case the general condition was very precarious before supra-malleolar amputation was made for tuberculosis of ankle; primary healing of wound and recovery of former weight and health. Similar instances have repeatedly come under my personal observation and could be indefinitely multiplied by cases from the general surgical literature, but enough has been said to show the value of efficient surgical treatment in peripheral tuberculosis, even if one or more of the internal organs are similarly affected. One of the sources of danger in chronic tuberculosis is fatty degeneration of the liver.

Louis and Andral called attention to the fact that fatty degeneration of this organ is met with more frequently in tuberculosis than any other disease. The degeneration commences around the tubercles and around the portal spaces, as if the tubercles and the contents of the ramifications of the portal vein exercised directly a steatogenic action on the contiguous hepatic cells. Tuberculosis of a joint may terminate in a spontaneous cure in cases in which the intensity of the infection is slight, or the resistance on the part of the patient is so great that

the fungous granulations do not undergo degenerative changes, but are converted into permanent connective tissue. A partial or complete synechia of the cavity of a tubercular joint is often one of the unavoidable results in such cases, leaving the joint in a permanently stiff condition. This endeavor on the part of the organism to limit the extension of the disease is often observed in cases in which the joint affection occurs in connection with osseous tuberculosis. As soon as perforation of a focus into a joint has occurred a wall of granulation tissue is thrown out around the circumscribed area of infection, and, under favorable circumstances, a partition of cicatricial tissue is formed which isolates the infected area from the intact portion of the joint. In such instances we have an illustration how the tubercular process is retarded, and sometimes permanently arrested, by the transformation of granulation into connective tissue. For such a favorable termination to take place, it is necessary that the tubercular virus should be attenuated by age or a want of proper nutrient medium, or that the pathogenic effect of the bacilli should be neutralized by an adequate resistance on the part of the tissues before degenerative changes have occurred in the granulation tissue. The course of articular tuberculosis is so variable in different cases that it is impossible, during the early stages of an attack, to predict anything certain in reference to the probable final outcome. A spontaneous cure is more likely to take place if the patient is young, not anæmic, and at the same time well nourished. The hygienic surroundings must also be taken into consideration in rendering a prognosis. The hereditary is more grave than the acquired form. The disease shows greater tendencies to limitation in children than in persons past the age of puberty. Among the different pathological varieties of joint tuberculosis, the tubercular hydrops and caries sicca are the most benign, and in these cases a spontaneous cure is most frequently realized, and the same conditions are also most amenable to successful surgical treatment. The caries sicca may, according to König, terminate in a spontaneous

cure in two or three years, with some loss of motion in the joint. It is often difficult to ascertain, in a given case, when the lesion can be considered as cured. As the most reliable evidences that such favorable termination has taken place must be considered disappearance of swelling, pain, tenderness and restoration of function as far as this can be expected. The patient should not be permitted to use the limb until the active symptoms of inflammation have disappeared. The danger to life arises from the existence of complications, foremost among them being septic infection, pulmonary or general tuberculosis, and amyloid degeneration of important internal organs. Septic infection is caused either by localization of pus-microbes brought to the tubercular focus through the circulating blood, or, what is more frequently the case, through an infection-atrium, created by a spontaneous opening through an operation wound, an exploratory puncture, or, finally, through a fistulous communication with the joint. Many neglected cases of joint tuberculosis die annually of pulmonary or general tuberculosis. Billroth states that in sixteen years 27 per cent. of all cases of bone and joint tuberculosis, under his observation, were lost in this way. König, from a table of one hundred and seventeen operations for tuberculosis, found that after four years 16 per cent. died of general tuberculosis. If a patient escape death from septic infection, after secondary infection with pus-microbes, he is liable to succumb several years later to amyloid degeneration of important internal organs, the spleen, the liver, and especially the kidneys, with its accompanying anasarca. *The prognosis must rest, then, in each individual case, upon the age of the patient, the location and extent of the disease, the general condition of the patient, and the presence or absence of complications.*

CHAPTER XIX.

Treatment of Tuberculosis of Joints.

General Treatment.—The successful treatment of a tubercular bone or joint affection requires that the patient should receive the benefits to be derived from both local and general treatment. The surgeon should not only make use of every local resource best calculated to cure or remove the local lesion, but must also possess and apply the knowledge and skill of an intelligent physician in the treatment of such cases. *The necessity of general treatment, hygienic, climatic, dietetic, and medical, must become apparent, if, as has been shown by clinical experience and post-mortem examinations, that the local affection in the bone or joint is, in the great majority of cases, but a manifestation of the existence of a tubercular focus in another and perhaps inaccessible part of the body.* A failure on the part of the surgeon to institute and carry out a rational course of general treatment would be as detrimental to the patient as a sole reliance upon it in curing the local affection. *Both extremes are equally dangerous, and should be carefully avoided.* Although it is a familiar fact that tubercular affections of bones and joints manifest an intrinsic tendency to progressive aggravation by local extension and systemic re-infection, cases of spontaneous cure under favorable conditions are by no means rare. *It may be laid down as a general rule that whatever contributes toward the improvement of the general health of the patient retards the progress of the local lesion and brings about the most favorable conditions for a spontaneous cure, and at the same time greatly adds to the success of operative treatment.*

Hygienic.—Hygienic treatment should not only be made use of as a curative agent in the treatment of tubercular disease of bones and joints, but is equally important as a prophylactic measure. Children born of tubercular parents should be surrounded by the most favorable hygienic conditions from the

time of birth until they reach the age of puberty, as the foundation for tubercular disease is usually laid during the period of growth and development of the skeleton. They should be carefully protected against inoculation with tubercular sputum, and all surface lesions, large and small, must receive careful attention in order to prevent the formation of an *infection-atrium*, through which tubercle bacilli might enter the general circulation, and from there become deposited in one or more of the bones and joints. *There can be but little doubt that, in persons with a general predisposition to tuberculosis, primary infection often takes place during infancy and childhood, through eczematous skin or insignificant traumatic defects of this structure.* In the same class of cases infection has often been traced to the use of milk from tubercular cows, and for this reason milk should not be given as an article of food unless it is rendered sterile by prolonged boiling. Infection through the respiratory tract should be guarded against by separating the child as much as possible from tubercular members of the family, and by providing for it a well-ventilated room, and by giving it the benefit of out-door air and exercise. Frequent bathing, preferably in salt water, followed by vigorous rubbing of the skin with a coarse bathing-towel, is of great value in maintaining a vigorous peripheral circulation, which is admirably adapted to prevent a passive hyperæmia in the parts anatomically predisposed to the localization of tubercle bacilli, and thus eliminate an indirect cause of tubercular affections of the bones and joints. Sudden chilling of the external surface of the body with its concomitant result, suppression of the cutaneous secretions, which is so often mentioned by patients as the immediate cause which precipitated an attack of bone or joint disease, must be prevented as far as possible by protecting the skin with flannel under-clothing, which should give way to silk or cotton only during the hot summer months. An abundance of nitrogenous food, adapted to the age of the patient, is an important element in the prophylaxis and treatment of tuberculosis of bones and

joints. A well-selected diet is of the utmost importance in maintaining nutrition and a normal quantitative and qualitative blood-supply,—conditions which are best calculated to prevent localization of floating tubercle bacilli in the bones and joints, as well as in other organs, and to check extension of the disease after it has become developed. Milk, cream, eggs, oysters, raw or rare roast meats, with a liberal allowance of fruit, are the articles of food best adapted to fulfill these indications. As regards food, Bidder ("Ueber zuwartende u. thätig eingreifende Behandlungsweisen der Gelenktuberculose." *Deutsche Zeitschrift f. Chirurgie*, B. xxi, Heft 2, p. 80), in speaking of the treatment of these diseases, lays stress on the avoidance of substances rich in potash, and also of starchy materials, and strongly advises the employment of albuminous foods rich in soda and fat.

A probable confirmation of this view is the noteworthy fact that tuberculosis is, as a rule, very common in herbivorous animals, and can usually be readily induced in them artificially by inoculation; while, on the other hand, it seldom occurs spontaneously in the carnivora, and these, as experiments show, have also proved more refractory to inoculation, feeding, and inhalation experiments. Man, who subsists on a mixed diet, stands midway between these two groups in his susceptibility to this disease, tuberculosis being more often local and less virulent than in the herbivora, while it is much more frequent and destructive than in the carnivora. In this way also Bidder explains the much greater frequency of tubercular diseases in the western part of Germany than in the eastern, although the density of the population is greater in the latter. It appears that the inhabitants of eastern Germany employ less vegetable diet than in the west, and eat large quantities of salt meat. Outdoor exercise should be insisted upon as an important prophylactic measure in persons predisposed to tuberculosis, and should be advised as an important part of treatment in all cases in which the character of the local lesion offers no contra-indication. A change of residence from a badly-ventilated room to

one supplied with an abundance of fresh air and sunshine, or from a home in an unhealthy to a more salubrious part of a city, or from an overcrowded city into the country, will often prove of the greatest value, both as a prophylactic and curative aid.

Change of Climate. — The prophylactic and therapeutic value of change of climate is almost universally recognized in the treatment of pulmonary tuberculosis. This method of treatment has yielded more favorable and lasting results than the use of drugs. There is no reason why the same treatment should not occasionally effect the same happy results in cases of tuberculosis of bones and joints if the affection occupies such a location, or is in such a condition as to justify removal of the patient. The favorable changes wrought by a change of climate are not always owing to improved climatic influences, but are very frequently attributable to an entire change of surroundings, which has a favorable influence in securing rest and in improving the appetite. A few weeks or months at the sea-side or at some mountain resort is often followed by a marked improvement of the local affection and the general health of the patient. For patients who are able to pay, such a change should be more frequently prescribed than has been customary heretofore in this country. The therapeutic value of thermal and mineral baths has been greatly overestimated, as the good results which have been obtained by sending patients to such health resorts should not be ascribed so much to the therapeutic action of the baths as to the change of climate and surroundings. In the selection of a proper climate for patients suffering from bone or joint tuberculosis a locality should be recommended where the patients can live most of the time out-doors. Patients in the North should spend the winter months in the South, and patients from the South are greatly benefited by living in the North during the summer months. The same care should be exercised in recommending a change of residence to the sea-shore or to a mountain resort.

Internal Medication.—So far we are not in possession of a single remedy which acts as a specific on tubercular tissue as the preparations of iodine do on syphilitic products. The drugs which have proved most useful are medicines which improve the general health. Bitter tonics are indicated when the appetite is poor, some preparation of iron when the patient is anæmic, and codliver-oil and its substitutes will prove beneficial in restoring flesh and strength in patients with unimpaired digestion. Codliver-oil should be given an hour and a half after meals, and in gradually increasing doses. Moeller's pale oil is the best, and does not disturb digestion as much as the different compounds of oil, iodine, etc., and the various emulsions sold at more than double the price of the more palatable pure oil. Among the preparations of iron, the iodide deserves special mention. It can be given as the syrup of the iodide of iron, in doses of from 15 drops to a teaspoonful some time after meals, or one to two Blancard's pills three times a day. At one time Langenbeck ("Ueber den Einfluss von Aresenik Behandlung auf Gelenktuberculose." *Deutsche Med. Wochenscrift*, B. x, p. 235) had faith in the administration of arsenic in the treatment of tubercular affections of bones and joints, and recommended its use especially in the after-treatment after resection. I have given the arsenic treatment a fair trial in different forms of surgical tuberculosis, either with negative or sometimes harmful results. Hofmokl ("Ueber die chirurgische Behandlung scrophulöser u. tuberculöser Leiden." *Wiener Med. Zeitung*, November 22, 1889) speaks well of the use of iodine, but I have never been able to satisfy myself that any of the many preparations of this drug had any influence in arresting or otherwise favorably influencing the tubercular process. Potassic iodide I have found useful in the treatment of tubercular lesions complicated with amyloid degeneration of the kidneys, as under its use in such cases the amount of albumen in the urine invariably decreased and the general health improved. That this preparation of iodine exerted a favorable influence on the kidneys was

shown by increase of the quantity of albumen which invariably occurred after suspension of its use. The administration of creasote, as advised by Sommerbrodt in the treatment of pulmonary tuberculosis, deserves a fair trial in the treatment of tubercular affections of bones and joints, as it now enjoys great popularity in the treatment of the former affection, and has yielded more favorable results than any other remedy heretofore suggested. Creasote should be given in one- or two-drop doses, made into a mass with balsam of Peru in a gelatin capsule, three or four times a day.

The different preparations of mercury which at one time had such great reputation in the treatment of tumor albus, used internally or externally, are not only useless but positively harmful in this and other forms of surgical tuberculosis.

Since 1878 Schüller ("Eine neue Behandlung der Tuberkulose." Berlin, 1891) has made a careful study of the therapeutic value of guaiacol in the treatment of different forms of tuberculosis. He first studied the effect of this drug on the growth of the tubercle bacillus in artificial nutrient media, and found that it had a decided influence in arresting further growth of the culture. He then made a series of experiments on animals which had been rendered tubercular by inoculation, and a decidedly curative effect was observed. The tubercular lesions were carefully examined at different times after the guaiacol treatment was commenced, and in many of the animals further extension of the tubercular process was not only arrested, but a permanent cure was effected, while all of the control animals died. In animals under the influence of guaiacol he observed, in the affected parts, three different processes by which the lesions were cured: (1) cicatricial contraction of the tubercles with central molecular degeneration, or fatty degeneration; (2) a peculiar softening of the nodules by the appearance of a fine intercellular net-work of juice-canals, followed by vascularization of tubercle tissue and corresponding changes of the cellular elements, particularly the giant-cells; (3) ulcerative destruction of

the tubercle, with consecutive cicatricial contraction and healing of ulcer. The guaiacol was administered by inhalation, by subcutaneous injection, or by the stomach. This author became satisfied long ago that external tuberculosis is only a peripheral manifestation of more deeply seated occult foci, and that all kinds of local treatment are inadequate to combat the disease successfully. It has been his endeavor to find some drug which, when administered in sufficient doses and for a requisite length of time, should prove efficient in curing inaccessible existing lesions, thus preventing re-infection of the body. Since 1885 he has subjected all of his tubercular patients to guaiacol treatment, in addition to appropriate local treatment. Of one hundred cases, seventy were cured, sixteen were improved, and four died; during the treatment only three died,—two of tubercular meningitis and one of an intercurrent diarrhœa. At first he administered the drug in the form of emulsion, but at the present time he gives it in milk, coffee, beer, or any other pleasant menstruum. According to the age of the patient, he gives from 2 to 5 drops four times a day. He places great stress on continuing this treatment for three months to a year and a half. In his interesting little book on this subject he gives a detailed account of over one hundred cases of different forms of tuberculosis treated by this drug, and the results obtained in many of the cases were certainly such that could not be attributed solely to the local treatment which was conscientiously employed at the same time. Local relapses and general dissemination were more effectually prevented than by any known local method of treatment unassisted by such general treatment. For the last four months every tubercular patient in my clinic and hospital practice has been placed on the guaiacol treatment, and, from the experience so far obtained, I believe, with the most happy results.

CHAPTER XX.

Local Treatment.

Although the existence of a tubercular bone or joint affection usually is only an indication of the presence of an older tubercular focus in some other part or organ, *the clinical fact remains that the primary focus frequently remains in a latent condition, and that re-infection is more likely to take place from the bone or joint lesion. It is on this account that the general treatment, no matter how well it may be planned and how admirably it may be executed, can never supplant the necessary local treatment. The local treatment consists of such means and measures which are best adapted to place the affected parts in the most favorable conditions to undergo a spontaneous cure, and if this, the ideal result, is no longer attainable on account of the extent of the disease or the character of the structural changes which have already taken place, the rendering harmless or elimination of the infected area for the purpose of preventing further local and general infection, and, if possible, to restore function of the infected part or limb.* The local treatment must, therefore, necessarily vary according to the location, extent of the disease, and the character of the inflammatory product. During the early stage of the disease, under favorable circumstances, the simplest local treatment may prove successful in arresting further progress, and in rendering the necessary assistance to bring about a spontaneous cure; while, on the other hand, if the disease is extensive, and the tissues have undergone irreparable changes, nothing short of a formidable and mutilating operation will answer the indications.

Rest.—One of the cardinal points in the treatment of inflammatory processes, irrespective of their cause or causes, is to secure for the inflamed part a condition approaching, as nearly as it is possible, *absolute physiological rest.* While it is generally conceded that it is necessary to secure rest in the treat-

ment of a tubercular affection of a bone or joint, there can be no doubt that this part of the treatment has been overdone, and has resulted in a great deal of harm to limb and patient. *It is one of the most difficult things in surgery to decide how long rest should be continued in the treatment of an inflamed joint. No absolute rules can be laid down to decide this matter.* Enforced rest, continued beyond the time it is required, has resulted in serious damage to joints in which an earlier suspension of this part of treatment would have yielded much better functional results. The injurious effects of prolonged rest on healthy joints have been made the subject of careful clinical and experimental studies. Volkmann ("Ueber den Hydarthros steif gehaltener Gelenke." *Berl. klin. Wochenschrift*, No. 30–31, 1870) reported, in 1870, twenty cases of effusion into otherwise healthy joints, that had been immobilized for a number of weeks in the treatment of fractures and adjacent diseased joints. The joint affection usually appeared soon after the patient made the first attempt to use the limb. The effusion, as a rule, made its appearance in a short time, and varied much as to amount. Volkmann attributes the hydrops to the rigidity of the synovial membrane and periarticular connective tissue, caused by the prolonged rest and immobilization. The movements in the joint produced harmful traction upon the shortened and rigid structures, producing distortion and its consequence, — *distortion-arthro-meningitis.* The effusion usually disappears spontaneously, as soon as the capsule of the joint is restored to its normal conditions.

In view of this experience, the author asserted that it was difficult for him to decide in how far rest and systematic use of a joint may be resorted to with greatest advantage in the treatment of chronic synovitis.

The late Professor Reyher, of St. Petersburg ("Ueber die Veränderungen der Gelenke bei dauernder Ruhe." *Deutsche Zeitschrift f. Chirurgie*, B. cxi, p. 189), made quite numerous experiments on young dogs to ascertain the effects of prolonged

uninterrupted rest on the structure of joints that had been perfectly immobilized in a plaster-of-Paris dressing. He found, in joints thus treated, that after the sixty-second day the articular cartilage, at points where the surfaces did not come in contact, had gradually been transformed into connective tissue. He maintained that the cartilage cells were transformed into connective-tissue cells. This transformation was first observed in the superficial layers of the cells; the process extended gradually deeper until the entire thickness of the cartilage became involved in this change. The capsule of the joint became thickened not from hyperplastic changes, but shrinkage of the tissues, which at the same time became more compact.

Menzel ("Ueber die Erkrankung der Gelenke bei dauernder Ruhe derselben." *Archiv für klinische Chirurgie*, B. xii, p. 990) made a similar series of experiments on rabbits. The time the joints were immobilized varied from a few weeks to sixty-eight days. He found that, in consequence of the prolonged rest, fibrous degeneration, erosion, and colloid softening of the articular cartilage occurred, *but he found these changes most marked at points where the pressure between the articular surfaces was greatest*, while Reyher found them in parts of the articular surfaces *not subjected to pressure*. He attributes these changes to the effect of prolonged pressure, as he found atrophic and degenerative changes most advanced where pressure was greatest and continued for the greatest length of time. He also found the synovial membrane changed, swelling, injection of vessels, desquamation of endothelial cells, and sometimes a pterygium-like proliferation.

These experiments furnish substantial evidence of the fact that rest, like all other valuable therapeutic measures, has its limits of application, and when these are surpassed it results in more harm than good. Rest is indicated as long as movements in the joint cause pain and the pain thus produced is due to inflammation of the structures of the joint; it is also absolutely necessary in the treatment of suppurating joints. Both active

and passive motion in a joint the seat of extensive disease must result in aggravation of the local conditions, and, at the same time, become a direct cause of local and general dissemination by forcing mechanically tubercle bacilli or even small fragments of infected tissue into the surrounding connective-tissue spaces or the veins. A joint often remains tender and painful for an indefinite period of time, even after all other evidences of inflammation have subsided, and it is in this class of cases that the best judgment is necessary to decide when it is best to substitute active and passive motion for rest. In tubercular hydrops of joints and in fungous synovitis moderate use of the joint does not interfere with the proper treatment for these affections, and immobilization in such cases is superfluous and often positively injurious. It is, however, entirely different in osteo-arthritis and advanced cases of primary synovial tuberculosis, as in these instances pain is a conspicuous symptom and is always aggravated by any attempt to move or use the joint; at the same time, the tendency in these cases to contractures is always apparent, and serious deformities can only be prevented or corrected by proper mechanical support. Extension of a primary osseous focus to an adjacent joint is hastened by use of the limb, and for this reason alone it would become necessary to secure rest for the joint in the treatment of primary tuberculosis of bone. Rest for an inflamed joint is secured in different ways, according to location of the disease and the intensity of the inflammatory process. The most perfect rest is attained by the recumbent position in bed, combined with immobilization of joint by a proper fixation dressing.

Rest in Bed.—The recumbent position secures for the extremities and the spinal column the most favorable conditions for rest, and if the inflamed part is at the same time placed in proper position it will be a valuable aid to the enfeebled circulation in the affected bone or joint. Enforced rest in bed becomes necessary in the treatment of most cases of hip-joint disease, with or without extension, and is indispensable in the

early treatment of tubercular spondylitis not amenable to treatment by extension and fixation in a plaster-of-Paris cast. In the latter class of cases the patient should be placed upon his back, with the affected portion of the spine resting on a Rauchfuss swing, securing thus, at the same time, rest and extension. As prolonged confinement in bed has an unfavorable effect on the general health of the patient, this part of treatment should not be prolonged beyond the time required to meet the local indications. A portable bed should be used in all cases requiring rest in bed for a long time, so that the patient can be taken from one room to another and, whenever practicable, into the open air without interrupting rest and extension, and at the same time reduce the danger incident to prolonged confinement by supplying an abundance of sunlight and pure air.

Immobilization of Joints.—Immobilization of a joint is not only indicated when a joint itself is the primary seat of the disease, as this method of treatment is also of great value in the treatment of tubercular disease of bone if the primary focus is located in the body of a vertebra or the epiphysial extremity of a long bone. Immobilization of the vertebral column in tubercular spondylitis can be effected most advantageously by extending the spine to the *point of comfort* and fixing the trunk in this position in a plaster-of-Paris dressing according to the method so fully perfected by Sayre. Rest and fixation of the shoulder-joint can be secured by placing the forearm in a sling and fastening the arm to the side of the chest with a broad strip of adhesive plaster or bandage encircling the chest. Cheap, comfortable, and useful fixation splints can be made of wire gauze, which is sold by the yard and can be cut into strips of the desired length and width with a pair of stout shears. These splints can be bent at any desirable angle, and can be molded accurately to the limb. When carefully padded with absorbent cotton they fit the limb accurately and give uniform, equable support. As a rule, they should embrace one-half or two-thirds of the circumference of the limb. The most efficient fixation

dressing is the permanent circular splint made of plaster-of-Paris, starch, dextrin, or water-glass. A splint of this kind must be applied with the greatest care, in order to prevent gangrene from circular constriction and decubitus from pressure. A layer of absorbent cotton, at least an inch thick, should surround the limb; and special padding over subcutaneous bony prominences must be provided for, and the splint applied from the periphery of the limb; starting, for instance, from the toes in using this dressing for the lower extremity, and from the metacarpo-phalangeal joints for the upper. Patients wearing a circular, plastic, permanent splint should always remain under the observation of the surgeon, and should be frequently seen in order to prevent disastrous consequences. Fixation splints for elbow- and wrist- joints should never extend farther than the base of the fingers, as when these are confined in the dressing in the extended position, even for a short time, more or less stiffness will surely result from the faulty position. In tubercular disease of the elbow-joint, requiring in its treatment long-continued rest and fixation, the forearm should be flexed upon the arm at right angles, and in a position half-way between pronation and supination, with the arm and forearm supported upon a posterior wire-gauze splint. Immobilization of the wrist-joint can be effectually attained by confining the forearm and dorsum of hand upon a posterior splint, with the hand in a straight or slightly extended position. The sling is a necessary supplementary appliance in connection with all fixation dressings of the upper extremity. In the treatment of bone and joint tuberculosis of the lower extremities, a fixation dressing is only to be applied when the limb is in a useful position or after it has been brought into such by appropriate treatment. Flexion of the thigh upon the pelvis in hip-joint disease, and of the leg in tubercular disease of the knee-joint, must be treated by rest in bed and extension by weight and pulley until the limb is brought into a useful position before either of these joints are immobilized. The only dressing which can fix the hip-joint completely is a

plaster-of-Paris dressing embracing the affected limb, the pelvis, and the opposite limb as far as the knee-joint. Fixation of the knee-joint, when the limb is in proper position, can be effected by the use of a hollow posterior splint extending from the tuberosity of the ischium the whole length of the limb, with a foot-board attached at right angles, against which the foot is fastened with a few strips of adhesive plaster or a roller bandage, or the limb is encased in a permanent, circular, fixation dressing. In the treatment of diseases of the ankle-joint the foot should always be placed at a right angle to the leg and then immobilized in this position. If there is a probability that the disease will terminate in complete or partial ankylosis, the joint should be immobilized in a position in which the limb will be of greatest use subsequently, which, in the hip- and knee-joints, is a slight degree of flexion: ankle-joint, foot at right angles to the leg; elbow-joint, forearm flexed so that the patient can reach the mouth with the hand, wrist straight. Whatever kind of fixation splint is used, it is necessary to remove it every few days or weeks for a thorough inspection of the joint and limb, and to ascertain if it is producing undue pressure at any point. The patient must be instructed in reference to the symptoms indicating such an occurrence and requested to report at once should these arise.

Extension.—As a therapeutic resource in surgery permanent extension was known to Guy de Chauliac; Heister mentions it, and Bell alludes to it in commenting upon the treatment of fractures of the femur. In America it was first used by Tyson, in 1819, and described ten years later. This method of treatment appears to have been entirely forgotten until it was again revived by Luke Howe (1824), Dugas (1839), and more recently by Gordon Buck. In 1830 Swift, of Easton, Pa., the preceptor of the late Prof. S. D. Gross, used strips of adhesive plaster for making the extension, and in 1844 Wallace introduced this technique as a routine treatment in the Pennsylvania Hospital, and the method was fully

described by Sargent the same year. Benj. Brodie was the first one to apply this method in the treatment of inflammation of joints; but the credit of establishing it as a legitimate procedure in practice in the treatment of joint affections belongs to G. Ross, who wrote elaborately on the subject in 1854. A great deal has been said and written on the value and *modus operandi* of permanent extension in the treatment of diseased joints. The more enthusiastic exponents of this method of treatment maintain that the beneficial results are due to a separation of the inflamed articular surfaces, while others claim that such an effect under ordinary circumstances is not realized, and that the beneficial results following its use are due entirely to the abatement of muscular spasms and the rest which it secures for the joint.

Volkmann ("Ueber die Behandlung der Gelenkentzündungen mit Gewichten." *Berl. klin. Wochenschrift*, Nos. 5–6, 1868) taught that permanent extension in the treatment of inflamed joints proves useful by diminishing the mutual pressure between the inflamed surfaces,—a doctrine strongly supported by Sayre and most orthopædic surgeons.

Schultze ("Untersuchungen über die Distractionsfähigkeit der Grossen Extremetätengelenke." *Deutsche Zeitschrift f. Chirurgie*, B. viii) believes that extension not only diminishes the mutual pressure between the articular ends of the bones, but that it can be carried to such an extent, in the treatment of inflamed joints, as to separate the surfaces completely. In his experiments on the cadaver he succeeded in separating the articular surfaces of the knee-joint under a traction of twenty-five pounds continued for forty-eight hours, one millimetre on the inner and one millimetre and a half on the outer side. If he immobilized the femur completely the same traction force in twenty-four hours doubled the diastasis.

In the shoulder-joint the separation effected under eight pounds of traction force amounted to three and a half millimetres. The same traction force produced a similar effect in

the wrist-joint. W. Busch ("Beiträge zur mechanischen Behandlung der Gelenkentzündung." *Archiv f. klin. Chirurgie*, B. xiv, p. 77) is of the opinion that the favorable results of the treatment of inflamed joints by extension is not owing so much to the separation by the traction of the diseased articular surfaces as to the shifting of the pressure-point within the joint, brought about by the gradual extension of the limb. He asserts that the extension of a contracted knee- or hip-joint does not diminish but increases the intra-articular pressure. He claims that the increased intra-articular pressure caused by the extension promotes absorption, and to this and the changed position of the limb he attributes the favorable results obtained by extension.

Lannelongue ("Notes cliniques et experiment. sur l'effet de l'extension continue sur les articulations malades et sur la coxalgie tuberculeuse la particulier." *Revue de Chir.*, vi, 2, p. 163) had an excellent opportunity to study the effect of extension on diseased joints in a child 4 years old, that had been suffering for five months from coxitis and died of croup. Treatment by extension had been carried out for forty-five days prior to death. After the death of the child extension was applied and the body frozen. Section through the joint showed that the articular surfaces were separated; and Lannelongue is of the opinion that this effect can be brought about by extension in diseased joints, and that to it should be attributed the beneficial results of this method of treatment. One of the first effects of extension in the treatment of coxitis is diminution of pain, especially the nocturnal exacerbations caused by the reflex muscular spasms; and as this result is obtained in primary osseous tuberculosis as well as when the joint is implicated, it is evidently the outcome of rest and cessation of muscular spasms, and not separation of the articular surfaces. In advanced cases of joint disease the ill effects of pressure-atrophy in the diseased articular extremities are diminished by the extension treatment. The same treatment also exerts an important orthopædic influence,

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as it brings the limb into the most desirable position and diminishes the liability to permanent contractures from pressure-atrophy and cicatricial contraction of the synovial membrane and capsule of the joint. Permanent extension is indicated in the treatment of inflammation of the hip- and knee- joints which has already given rise to muscular contraction and deformity. In the absence of these secondary results it is better to resort to some of the different immobilization dressings which will not confine the patient to his bed. Extension is a safe and exceedingly valuable resource in the prevention and correction of recent contractures about the knee- and hip- joints. The simplest method to make extension is by the use of weight and pulley. Ordinary adhesive plaster is very prone to cause irritation of the skin in young children and in persons with a thin, delicate skin, and on this account a non-irritating adhesive substance should be used. Either the ordinary lead plaster or the English moleskin adhesive plaster answers an excellent purpose. *The great rule which should guide the surgeon in making extension of a limb that has become contracted by tubercular disease of a joint or one or more of the epiphysial extremities is to make first the traction in the direction of the faulty axis, and only gradually change the angle until the desired position is reached.* If the thigh is much flexed in hip-joint disease or the leg in inflammation of the knee-joint it will often be found advantageous to place the limb upon a double inclined plane, and in the former case apply extension to the thigh alone in the direction the limb has assumed and gradually diminish the angle of the inclined plane until this can be dispensed with and extension applied in the usual way. In the latter case the same precautions are carried out. Extension in the normal axis of the limb in such cases can often not be borne on account of the pain which it causes; at the same time, by increasing the pressure between the articular surfaces at a point where the disease is most advanced, it would rather favor than prevent subluxation. The amount of traction to be employed must necessarily vary

from two to twenty-five pounds, according to the age of the patient and the nature of the indications to be fulfilled. The safest rule to follow is to commence with a small weight and gradually increase it until the proper amount is reached. Extension is only the preparatory treatment for the use of a fixation dressing, and should be suspended as soon as the limb has been brought into a useful position, as when it is continued beyond this time it ceases to be of any benefit and may seriously impair the subsequent functional utility of the joint. Contra-exten-

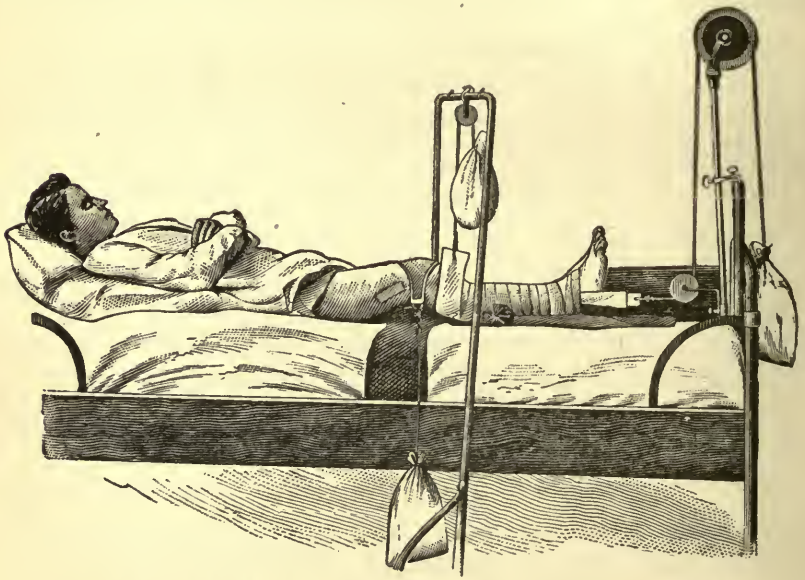

FIG. 32.—PERMANENT EXTENSION BY WEIGHT AND PULLEY IN THREE DIRECTIONS IN DISEASE OF THE KNEE-JOINT WHICH WAS CAUSED BY FLEXION AND SUBLUXATION OF THE TIBIA BACKWARD. (*Krause.*)

sion is made by the weight of the body by raising the foot of the bed. Direct contra-extension is unnecessary and a source of great inconvenience and often of actual suffering to the patient. In some cases it is necessary to make extension in more than one direction for the purpose of correcting deformities caused by the intra-articular disease. Fig. 32 furnishes a good illustration of the indications and application of multiple extension in the treatment of inflamed and deformed joints.

Hutchinson, of Brooklyn ("On the Mechanical Treatment of Chronic Inflammation of the Hip-, Knee-, and Ankle- Joints by a Simple and Efficient Method, the Physiological Method, with Cases." *Medical Record*, No. 10, 1879), has devised a very simple and yet effective method of making extension in the treatment of the larger joints of the lower extremity. The patient is made to walk on crutches, the healthy limb being supplied with a shoe provided with a raised sole. The affected limb being suspended makes the necessary extension by its own weight; so that this simple device secures both rest and extension, while the patient has the benefit of out-door air and exercise. Hutchinson claims that in coxitis the numerous muscles surrounding the hip-joint immobilize the joint sufficiently, while in the treatment of inflammation of the knee- and ankle- joints he advises immobilization by some kind of a fixation dressing in connection with the auto-suspension treatment. This method of making extension is of special utility in the treatment of affections of the large joints of the lower extremity during the early stage. It is also valuable in the after-treatment of cases in which by previous treatment the inflammation has been lessened and deformity corrected, as well as after excision of joints as soon as the patient is able to leave his bed.

Portable Extension Apparatus.—Recognizing the deleterious effects of prolonged rest in bed, necessitated by making permanent extension, on the general health of patients suffering from tubercular affections of the large joints of the lower extremity, orthopædic surgeons have devised a number of ingenious instruments with the expectation that they would answer the same purpose as permanent extension minus the disadvantages incident to in-door confinement. The instruments best known, and which have given most satisfaction, are those invented by Taylor, Davis, Sayre, Volkmann, Bauer, Hutchinson, and Thomas. The more costly and complicated instruments are now seldom used. The one which is used most now in the treatment of hip-joint disease is the Thomas splint. It is the

simplest, cheapest, and yet the most efficient apparatus in limiting motion in the hip-joint in patients that are able to walk on crutches. The claim made for these instruments that they, if properly applied, would prevent pressure between the joint surfaces is unfounded. No patient would bear for any length of time the amount of traction and counter-traction to accomplish this object. None of these splints are of any use unless the limb is nearly in a straight position, and they are, therefore, at best only supplementary aids to permanent extension, in the majority of cases. Hutchinson's method of suspending the affected limb makes more efficient extension than any of the so-called *extension splints*, while immobilization is more perfectly attained by some one of the fixation dressings already referred to. A circular or removable fixation splint, combined with extension, as advised by Hutchinson, is by far a more efficient treatment than the use of extension splints, and, at the same time, more comfortable to the patient.

CHAPTER XXI.

Local Treatment (*continued*).

Brisement Forcé.—The rapid correction of deformities produced by paralysis, inflammation of bones and joints, is called *brisement forcé* or *redressement.* Forcible extension of a contracted limb is now less frequently resorted to, because experience has shown that efforts of this kind have often been followed by an acute destructive inflammation of the joint, and in operations done for tubercular affections, even by miliary tuberculosis. (*Verchère Progrès Médical*, 1886, No. 24.) This procedure should be limited to recent cases if for any reasons permanent extension is not applicable or has proved inefficient, and, later, again after the inflammatory process has subsided and has left the limb in a contracted condition. It is positively contra-indicated if fistulous openings lead into a suppurating joint, and if thin scars adherent to the articular extremities are in the way of complete extension, as such scars are liable to be torn by the sudden efforts to straighten the limb,—an accident which might lead to serious results. It is also not applicable in cases where the disease has resulted in partial dislocation of the articular extremities, as under such circumstances the forcible straightening of the limb might increase or complete the dislocation. This is especially true in the case of partial dislocation of the head of the tibia backward with outward rotation of the leg. In well-selected cases this method of treatment expedites the cure and places the limb at once in a useful position. In the second class of cases intra-articular adhesions and muscular contractures are to be overcome by manual force. It is necessary to operate under full anæsthesia in order to remove all resistance caused by muscular contractions. The amount of force to be employed must, of course, depend on the age of the patient, the size of the joint, the degree of deformity, and the nature of the mechanical difficulties which have to be overcome. A great

deal of good judgment is necessary in grading the force in each case. In children, a force necessary to correct a faulty position, due to partial or fibrous ankylosis, may produce a fracture through the epiphysial line. If the muscles on the flexor side have become so much shortened as to offer the principal resistance to extension, tenotomy or myotomy should be done before a forcible attempt is made to straighten the limb. If the intra-articular adhesions are so firm that it would require an undue amount of force to correct the faulty position at one sitting, it is safer to be content with a partial result and repeat the effort after two or three weeks, making use during the interval of permanent extension. If a safe amount of force yield little or no gain, *brisement forcé* should give way to an osteotomy or excision, as both of these operations are less dangerous than the use of undue violence, and will enable the surgeon to place the limb in a position adapted to a favorable functional result. If the *redressement* prove successful, the limb is placed in a desirable position and immobilized until the reaction following the operation has subsided. If the intra-articular conditions are such that it appears possible and desirable to obtain a movable joint, active and passive motion are now instituted; and if a tendency to recurrence of deformity is observed, permanent extension or a fixation dressing is to be relied upon in maintaining what has been gained by the *redressement*. If the articular surfaces have been so much changed by the inflammatory process as to preclude the possibility of obtaining a movable useful joint, the limb is to be kept immobilized in proper position until the ankylosis has become sufficiently firm to prevent recurrence of the deformity.

External Local Treatment.—A correct knowledge of the true etiology of bone and joint tuberculosis has done away with the time-honored external local treatment, consisting of cupping, leeching, blistering, poultices, lotions, plasters, salves, etc. Modern surgery has shown that the use of external remedies of every description exert no direct healing powers on the intra-osseous

or intra-articular lesions, and that all the best of them can accomplish is to improve the circulation in the affected parts, and thus indirectly influence favorably the healing process.

Compression.—The value of equable, long-continued compression of parts the seat of chronic inflammation is well known. The artificial external support supplied in this manner assists the weakened, inflamed capillary vessels and promotes the absorption of the inflammatory product. This therapeutic measure is of no value in the treatment of bone tuberculosis as long as the inflammatory process remains intra-osseous. Its beneficial effect is most marked in fungous synovitis and after tapping or aspiration of a joint for tubercular hydrops. Circular compression made with a flannel or elastic bandage or strips of adhesive plaster requires great care, as, in case the circular constriction is too firmly applied, it might interfere with or arrest completely the circulation in the peripheral portion of the limb. In making circular compression of a joint the limb must be carefully bandaged from the periphery as far as the joint, which is then supported by strips of adhesive plaster, which are made to cross each other in front at an obtuse angle; or the joint and the limb, for some distance below and above it, is compressed with an elastic-webbing bandage, which is applied with sufficient firmness to give uniform support without interfering with the circulation in the deep vessels. In some cases it is advisable to combine compression with fixation of the joint. These objects are attained to a certain degree by a circular fixation dressing, by interposing between the joint and the splint a thick layer of absorbent cotton, light pressure being made by the elastic-cotton compress. In other cases, especially in the treatment of chronic inflammation of the knee-joint, the limb is bandaged from the toes to the knee-joint and fixation secured upon a posterior hollow splint, when compression is made with strips of adhesive plaster, which encircle the anterior portion of the joint and the splint. This method of making compression is particularly useful after tapping the knee for tubercular hydrops.

As the compression should be continuous, the dressing must be changed as often as it becomes loose.

Cold.—This therapeutic agent has no direct influence in removing the cause of tubercular inflammation, but has proved serviceable in favorably modifying the inflammatory process when used at the right time and in a proper manner. If used indiscriminately and empirically it will result in harm. Cold is a potent agent for good or harm, according to the stage of inflammation during which it is applied. The sensation of heat, both subjective and objective, naturally suggested the use of this remedy. The application of cold to an inflamed bone or joint superficially located is of benefit during the early stage of inflammation, at a time when exudation and transudation are only beginning and the capillary vessels are dilated and only partially obstructed. *Tubercular inflammation, as it affects bones and joints, is a chronic process, made up of successive attacks of acute exacerbations, of shorter or longer duration and greater or lesser intensity.* Cold, when applied during these acute attacks, becomes a valuable remedial agent (1) by producing contraction of the small blood-vessels; (2) by producing at least an inhibitory effect upon the tubercle bacilli in the inflamed tissues. *The contraction of blood-vessels, which takes place under the application of cold, has a tendency to clear the stagnated capillaries of their surplus contents and to prevent further mural implantation of bacilli or infected leucocytes.* Microbes in the tissues can only multiply at a certain temperature, and if this can be kept at a point low enough to prevent their increase, without injury to the tissues, by the prolonged application of cold, this agent fulfills, at least in part, one of the causal indications in the treatment of inflammation. *If, however, stasis has already taken place in the capillaries first affected, the application of cold will prove harmful, as it will tend to prevent the formation of an adequate collateral circulation.* This agent will therefore prove beneficial in the treatment of tubercular bone and joint disease during its early

stages and during the interval of acute exacerbations. Employed at such times, its use is often followed by diminution of pain, swelling, and tenderness, and initiates a process of repair. If its use is not followed within a short time by improvements such as have been enumerated it is evident that the proper indications are not present in the case, and its further use should be dispensed with. When it appears desirable to resort to the use of cold, this remedy should be applied in the form of an ice-bag. The part to which the ice-bag is to be applied can be covered with several layers of a wet towel, as, otherwise, the prolonged use of the direct application of ice may not secure the comfort desired and may endanger the superficial circulation. *The sensations of the patient can be accepted as a safe guide as to the degree of cold to be used and the length of time it should be continued.*

Antiseptic Fomentations. — If cold applications are not agreeable to the patient, or if they are not indicated by the location of the disease or the stage of the inflammatory process, warm fomentations can often be substituted for them with benefit to the patient and to favor the reparative process. External heat stimulates the peripheral capillaries and relieves internal congestions, and in doing so acts favorably on a deep-seated tubercular focus in a bone or joint. The old-fashioned filthy poultice of flaxseed, slippery elm, bread and milk, and the many unmentionable, disgusting substances that have been used for centuries in the treatment of localized inflammation, have no longer a place among the resources of the modern aseptic surgeon. *The common poultice is a hot-bed for pathogenic bacteria, and, as such, it should be discarded.* The surface to which a fomentation is to be applied should be thoroughly cleansed with warm water and potash soap. Priesnitz's ordinary local hydropathic pack answers often an excellent purpose in relieving pain and in stimulating the reparative process around a tubercular focus. A thick compress wrung out of hot water is made to envelop the limb for some distance beyond the part affected or

to cover the inflamed area in other parts, and heat and moisture are retained by covering it with some impermeable substance such as oiled silk, thin rubber sheeting, or gutta-percha tissue, and the dressing is retained by an appropriate bandage. *As a certain quantity of medicinal substances held in solution and applied to the cutaneous surface for a long time reaches the tissues by absorption through the skin, it is advisable to apply antiseptic solutions in place of simple water in the treatment of a localized infective inflammation, in the hope that even small quantities of the antiseptic substance employed may exert an inhibitory effect on the microbes residing in the tissues.* Only such substances and solutions of such strength should be used for this purpose that their prolonged application will not be attended by danger of producing intoxication. In the treatment of tubercular inflammation of bones and joints by hot fomentations, I would recommend iodine-water, a solution of corrosive sublimate 1 to 5000, carbolic acid 1 to 100, or boric acid 5 to 100. Absorption through the skin of the antiseptic substance used will have a direct influence in diminishing the intensity of the primary cause which produced the inflammation, and prepares, in an admirable manner, the field for any operation which may become necessary in the future.

Massage.—This local measure is more applicable in the treatment of some of the results than the tubercular inflammation itself. Tuberculosis of bones and joints is always attended by atrophy of the muscles of the affected limb, and in the case of joints even the most favorable termination almost always leaves more or less stiffness in the joint, and it is in the correction of these two consequences of the tubercular affection that massage yields satisfactory results. *Massage of a joint the seat of an active tubercular inflammation aggravates the local conditions and might become a direct cause of metastatic foci in other organs.* After the inflammatory symptoms have subsided, systematic massage, scientifically practiced, is an exceedingly important and valuable therapeutic resource. It stimulates the

surrounding vessels to increased action, and exerts a potent influence in restoring the normal circulation in the affected capillary vessels, promotes absorption and increases nutrition of the wasted atrophic muscles. The masseur should be instructed to apply some absorbent preparation before the frictions and manipulations are made, as the endermic use of absorbent drugs in this manner will increase the efficacy of the treatment. A drachm of potassic iodide or half a drachm of iodoform to an ounce of lanolin or sanitas will be an excellent preparation for this purpose. Cold and hot douches, passive and active motion, combined with massage, will often expedite a cure by increasing the circulation and nutrition of the part or limb.

Counter-irritation.—The idea that an inflammation artificially produced in the vicinity of an inflamed bone or joint would exert a curative influence, that prevailed for such a long time and received the support of the most prominent surgeons, is no longer tenable. Cauterization, blistering, seton, moxa, and the application of tincture of iodine in full strength, and other irritants are not only useless in the treatment of bone and joint tuberculosis, but positively harmful. *Anything which destroys the continuity of the skin over a tubercular focus adds to the suffering of the patient and may create an infection-atrium for secondary infection.* Mercurial inunctions, of value in the treatment of syphilitic bone and joint affections, are positively contra-indicated in the treatment of tubercular lesions. As patients and their friends always entertain the highest opinion of the utility of external applications, it is often necessary, in order to retain their confidence, to prescribe an absorbent non-irritating ointment to prevent them from passing into the hands of charlatans before the time has arrived to resort to more effective and radical measures.

Electricity.—Neither the constant nor the faradic current can have a curative effect on the tubercular lesion, but both are useful in the treatment of one of the most constant remote effects of tubercular processes in bones and joints,—muscular

atrophy. The use of electricity must, therefore, be reserved for cases in which the tubercular process has been arrested spontaneously or by appropriate treatment, for the purpose of bettering the functional result. This part of the treatment should not be entrusted to the patient or non-professional persons, but should be carried out by the attending physician or some person fully competent under his supervision. Massage and electricity are indicated in the same class of cases, and one should be supplementary to the other.

Tapping of Joint.—Saxtorph ("Kasuistiske Meddelelser fra Frederiks Hospital chirurgiske Afdeling. Det. Kgl. medicinske Selskab. Forhandl. Bibliothek f. Läger," B. xx, S. 167) was one of the first to resort to the trocar as a therapeutic resource in the treatment of chronic synovitis with effusion. He evacuated the joint with an ordinary trocar, after which he immobilized the joint and enforced rest in bed for two weeks. He reported thirteen cases treated by this method, and had never observed any unpleasant consequences which could be traced to the operation.

The value of repeated tappings of hydropic joints was prominently brought to the attention of the profession in this country by Bauer, of St. Louis. ("Clinical Lecture on Hydrarthos, Hæmato-arthrosis, and Perforating Wounds of the Knee-Joint." *St. Louis Medical and Surgical Journal*, July, 1870.) He spoke especially of the advantages pertaining to tapping for hydrops of the knee-joint. Before puncturing he forced the fluid into the upper recess of the joint by bandages and compresses and exercised great care in guarding against the entrance of air into the joint through the cannula of the trocar. After evacuation of the joint he applied compression with graduated compresses and strips of adhesive plaster, and confined the limb upon a straight posterior splint. Since the introduction of the aspirator by Dieulafoy this instrument has partially displaced the trocar in the removal of fluid from joints, and we now speak of aspiration as well as tapping of joints.

The aspirator gives greater security against the entrance of air than the trocar in the hands of surgeons whose experience with this kind of treatment is limited. With proper care, however, this accident can be prevented with certainty in using the trocar. If, as is now customary, the evacuation of a joint is followed by intra-articular irrigation and medication, a trocar is preferable to an aspirator. Carelessness in the use of the latter instrument is attended by great danger, as it has happened that, instead of making aspiration, air was injected into the joint, and in one case, which has been reported, this accident was the cause of sudden death on the operating-table; the injected air undoubtedly found its way into the veins, and death resulted from air-embolism. In using either of these instruments it is necessary to resort to strict antiseptic precautions to guard effectually against secondary infection. The instruments should be sterilized by boiling or by heating them sufficiently by passing them through the flame of an alcohol-lamp. The site for the puncture must be thoroughly disinfected. Before the puncture is made the skin should be drawn to one side, so that, after the removal of the cannula or needle, the deep puncture may be subcutaneous. The point where the puncture is to be made should be carefully ascertained for each individual joint. *As a rule, a place should be selected where the joint is nearest to the surface.* In tapping the hip-joint the puncture is made at the upper margin of the great trochanter, at a point equidistant from its anterior and posterior border, from where the instrument is plunged in a downward and inward direction until its point has reached the neck of the femur, when the thigh is adducted and the instrument advanced until solid resistance is again met with. The knee-joint is most accessible at a point corresponding with the upper recess of the synovial sac, on the outer side, a little above and external to the patella. The instrument should be inserted boldly until its point is underneath the patella. In tapping the ankle-joint the foot should be extended and the puncture made at a point anteriorly corresponding

with the anterior border of the external malleolus, near its base. The spaces between the different tarsal bones are punctured in places most accessible from the external surface. The shoulder-joint can be reached with equal ease from the front and from behind. The elbow-joint is accessible, by the shortest and most direct route, by puncturing at the outer border of the olecranon process, at a point half-way between its base and tip, entering the joint between the head of the radius and outer condyle of femur.

The wrist-joint can be tapped from the radial, ulnar, or dorsal side, and when the operation is to be repeated it is advisable to alternate between these different places. In tubercular hydrops the intra-articular effusion is often very copious, resulting in enormous distension of the capsule of the joint, which, if continued for any length of time, must necessarily result in great weakening of the joint. Tapping or aspiration, under these circumstances, relieves the distension and places the vessels in the synovial membrane in a better condition to perform their function in the subsequent removal of the inflammatory product by absorption. If the tapping is not followed by iodoformization, which is now generally practiced in such cases, the limb should be immobilized and rapid re-accumulation of fluid prevented by uniform, equable compression of the joint by strips of adhesive plaster or carefully regulated pressure by a rubber-webbing bandage.

CHAPTER XXII.

Tuberculin Treatment.

Soon after Koch delivered his famous address at the Berlin International Medical Congress, he made known the application of the chemical substance which was prepared in his laboratory for the treatment of tuberculosis (*Deutsche Med. Wochenschrift*, November 14, 1890; extra edition *Medical News*, November 15, 1890). The remedy is a brownish, transparent liquid, which does not require special care to prevent decomposition. For use, this fluid must be more or less diluted, and the dilutions are liable to undergo decomposition if prepared with distilled water. As bacterial growths soon develop in them they become turbid, and are then unfit for use. To prevent this the diluted liquid must be sterilized by heat and preserved under a cotton-wool stopper, or, more conveniently, prepared with a ½-per-cent. solution of carbolic acid. As the remedy appears to be weakened by frequent heating and the admixture of antiseptics, it is advisable to use a freshly-prepared solution. The instrument used for making the injections is the bacteriological syringe devised by Koch which has no piston, but instead is furnished with a rubber ball. This syringe is easily kept aseptic by the use of absolute alcohol.

Fig. 33.—Koch's Syringe.

The place chosen for the injection was the skin of the back between the shoulder-blades and the lumbar region.

As regards the effect of the remedy, a healthy guinea-pig will bear a subcutaneous injection of 2 cubic centimetres, and even more, of the liquid without being sensibly affected; but in the case of a full-grown, healthy man 0.25 cubic centimetre suffices to produce an intense effect. A healthy person reacts

either not at all or scarcely at all when 0.01 cubic centimetre is used. A dose of 0.01 cubic centimetre injected subcutaneously into tubercular patients causes a severe general reaction as well as a local one. The general reaction consists in an attack of fever, which usually begins with rigors and raises the temperature above 39°, often up to 40°, and even 41° C. This is accompanied by pain in the limbs, coughing, great fatigue, and often nausea and vomiting.

In several cases a slight icteroid discoloration was observed, and occasionally an eruption like measles on the chest and neck. The attack usually begins four or five hours after the injection, and lasts from twelve to fifteen hours. Occasionally it begins later and then runs its course with less intensity. The febrile attack leaves the patient subjectively in a better condition than before the injection. The local reaction can be studied to the best advantage in cases in which the tubercular affection is visible. For instance, in cases of lupus, changes take place which show the specific antitubercular action of the remedy to a most surprising degree. A few hours after an injection into the skin of the back,—that is, in a spot far removed from the diseased area on the face or elsewhere,—the lupus begins to swell and to redden, and this it does generally before the initial rigor. During the fever the swelling and redness increase, and may finally reach a high degree, so that the lupous tissue becomes brownish and necrotic in places where the growth was sharply defined. After the subsidence of the fever, the swelling of the lupous tissue gradually decreases and disappears in about two or three days. The lupous spots themselves are then covered by a soft deposit, which filters outward and dries in the air. The growth then changes to a crust, which falls off after two or three weeks, and which, sometimes after only one injection, leaves a clean, red cicatrix behind. Generally, however, several injections are required for the complete removal of the lupous tissue. It appears that the fluid injected possesses a special predilection for tubercular tissue, and upon which it exerts its specific action.

PLATE VII.

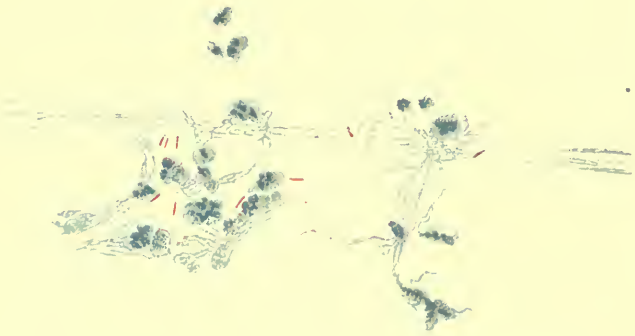

FIG. 34.—BACILLI BEFORE INJECTION. (Koch.)

FIG. 35.—BACILLI AFTER INJECTION. (Koch.)

In the treatment of tubercular affections of the glands, joints, bones, etc., by the same method, the parts affected, a few hours after the injections, become more painful, swollen, and red. As only tubercular tissue and tubercular patients react after the injection of an ordinary dose of lymph, the injection proves as reliable in diagnosis as useful in the treatment of nearly all forms of localized tubercular processes. In tubercular patients subjected to this treatment, the effect of the succeeding injections will show when the primary cause of the disease has been removed, or, at least, rendered harmless.

Koch maintains that the remedy does not kill the tubercle bacilli, but the tubercular tissue, and this gives us clearly and definitely the limit that bounds the action of the remedy. (Plate VII, Figs. 34 and 35.)

The action of the remedy is limited to living tubercular tissue, and it has no effect on necrotic or caseous tubercular material. The fact that the remedy makes tubercular tissue necrotic and acts only on the living tissue helps to explain the circumstance that it cannot be administered safely in rapidly increasing doses. In the different forms of surgical tuberculosis uncomplicated by advanced pulmonary phthisis, the treatment can be commenced by injecting 0.1 cubic centimetre, the same dose to be repeated after a week or two, continuing in the same way until the reaction becomes weaker and weaker, and finally ceases entirely,—an indication that the process has become completely arrested. Phthisical patients reacted strongly to 0.002 cubic centimetre, but gradually became tolerant to larger doses. The first publication on the treatment of tubercular affections of joints and bones by Koch's method was made by Bergmann (*Journal American Medical Association*, December 20, 1890), who had tried it in sixteen cases, some of them having advanced to the formation of abscesses and fistulæ. Some of these, to whom a first injection had been applied, showed the usual symptoms; the joints were much swollen and highly colored, and movement was scarcely possible. Others had been

treated by repeated injections. One of these, who suffered from pulmonary phthisis and tubercular inflammation of the knee-joint, was so severely affected by the injections (intermittent pulse, faintness, etc.) that there seemed cause for anxiety. He had, however, recovered, and was progressing favorably. In summing up the cases Bergmann said that, from the local and general symptoms which had already shown themselves, the prognosis was decidedly favorable. Nevertheless, in many cases surgical operations would still be unavoidable, as abscesses and dislocations could only be cured by mechanical means. In these cases it would be of the highest importance to guard against relapse by the repetition of Koch's treatment, and thus both methods combined gave the brightest prospect of success.

E. Hahn (*Deutsche Med. Wochenschrift*, January 1, 1891) reports 59 cases of surgical tuberculosis subjected to Koch's treatment. In 32 of these the treatment had advanced sufficiently to show its merits; 16 were considerably, and 12 appreciably, benefited; in 4 no change was perceptible. In cases of tubercular joint and bone disease, the results were better when sinuses existed than in others in which there was neither sinus nor surgical opening. In one case, in which the knee-joint was resected, reaction, which had been very strong before the operation, entirely ceased after it.

Hans Schmid (*ibid.*) reports the effects observed in sixty patients in the Bethany Hospital at Stettin. The treatment proved satisfactory, and high hopes were entertained in regard to the final beneficial results.

Socin (*Carsp u. Correspondenzblatt f. Schweizerärtze*, 1891, No. 1, p. 91) tried the method in twenty cases, and from his observations he was in doubt as to the healing powers of the fluid. He believes the knife will still have to be relied upon as heretofore, but at the same time he thinks there can be no doubt that the new method will enable surgeons to operate with greater certainty and with more satisfactory results.

Lindner (*Deutsche Med. Wochenschrift*, December 18,

1890) reports two cases in which, although no reaction whatever followed the injections, the local condition was considerably improved. A man who had been operated on for disease of the elbow-joint, judged to be of a tubercular nature, still suffered from painful swelling in the joint, together with a fistula which could not be made to heal. After several injections of Koch's fluid, though no reaction had occurred, the fistula closed, the swelling disappeared, and the movement of the joint was restored. The other patient was a man who had a large number of fistulæ over the sternum and considerable tubercular lesions in the lungs. Injections even of doses of 3 centigrammes caused no reaction; nevertheless, at the end of a fortnight, the greater number of fistulæ had healed, and the few that remained the openings scarcely admitted the end of the probe.

Helferich (*Deutsche Med. Wochenschrift*, No. 50, 1890) speaks very hopefully of the treatment, of which he says he can only compare it with that of antisepsis. He compares the specific effect of the fluid on tubercle to that of mercury and iodide of potassium on syphilis. In four cases of hip-joint disease it was noticed that the local pain caused by reaction was less severe when the ordinary extension treatment was employed. With regard to the general reaction, Helferich observed that frequently the second and third injections of the same dose were followed by a higher fever than the first; that the interval between the injection and the commencement of reaction is longest after the first injection, and becomes gradually less as the treatment is continued; that the highest degree of temperature is most speedily reached after the second and third injections; and that the duration of the fever, after doses of the same strength, is shorter after several injections have been given than at first.

Verneuil (*Union Médical*, January 22 and 24, 1891) claims that an authentic and permanent cure by the use of Koch's lymph has yet to be recorded; temporary benefit has been observed in a few cases; serious complications arising in

healthy organs have been frequent, and a very considerable number of deaths, owing to aggravation of the local condition, to lesion of healthy organs, or to fresh infection by the lymph, have been reported. He maintains that it cannot be relied upon as a means of diagnosis, and, owing to the danger which attends the local reaction, the degree of which cannot be foreseen, it would, he thinks, be desirable to make use of the remedy as a diagnostic agent only if it were actually indispensable for diagnosis, which, he contends, is not the case.

Feilchenfeld ("Ueber den Verlauf einiger mit dem Koch'schen Heilmittel behandelten Fälle von Tuberculose verschiedener Organe." *Therap. Mon. Hefte*, November, 1890) made the claim that in a number of cases of osteo-arthritis a definite cure had been effected by tuberculin injections. Among the more important papers detailing favorable experiences with Koch's lymph in the treatment of surgical tuberculosis may be mentioned "Bericht über die Anwendung des Koch'schen Heilmittels bei Kranken," von Esmarch (*Deutsche Med. Wochenschrift*, Nos. 3–4, 1891); "Mittheilungen über das Koch'sche Heilverfahren," H. von Burckhardt (Med. Corresp. *Blatt des Würt. ärzt. Landesvereins*, December 18, 1890); "Das Koch'sche Heilverfahren combinirt mit chir. Eingriffen," Sonnenburg (*Deutsche Med. Wochenschrift*, No. 1, 1891); "Mittheilungen über das Koch'sche Heilverfahren aus dem Kaiser Franz Josef Kinderspital in Prag," Ganghofer u. Bayer (*Prager Med. Wochenschrift*, No. 34, 1891); "Das Koch'sche Heilverfahren im Spital Münsterlingen," Kappeler (*Correspondenzblatt für Schweizeraerzte*, 1891).

At the Second Congress of Tuberculosis, July 27 to August 2, 1891, Arloing, Rodet, and Courmont presented a communication on "Experimental Studies of the Properties Attributed to Koch's Tuberculin." In this paper they gave the results of their own investigations concerning the three principal properties attributed to Koch's lymph—its curative effect, its diagnostic value, and its prophylactic properties.

They found, as one of its most constant effects, a rise in temperature, which, however, is always preceded by a prodromic stage, which seems to indicate that the fever is not produced directly by tuberculin, but probably by a phlogistic substance, which forms by the action of tuberculin on the tissues. They place no absolute reliance on its diagnostic value. From a therapeutic point of view, these authors have found Koch's lymph useless in the case of bird, bovine, or human tuberculosis in animals. Finally, these experimenters attempted to verify the assertion of Koch, made at the International Medical Congress, that the guinea-pig was rendered immune to tuberculosis by treatment with tuberculin; they found, on the contrary, that in many cases these animals were thus rendered much more susceptible to tubercular lesions; in fact, that the lesions were much more confluent and showed greater tendencies to speedy disintegration.

The concluding remarks on tuberculin treatment are taken mostly from a paper on "Away with Koch's Lymph!" which I had the honor to read at a meeting of the Chicago Medical Society, May 18, 1891, and which was published in the *Chicago Medical Recorder*, June, 1891. In this paper a brief history and the immediate and remote results of the treatment are given in 53 cases of tuberculosis, of which 43 were cases of pulmonary phthisis and 10 cases of surgical tuberculosis, and of the latter 4 were cases of joint and bone affections. Only the last 4 cases will be reported in full.

"When, six months ago, the telegraph operator at Berlin touched the key of his instrument and flashed to all parts of the civilized world the joyful tidings that a cure for tuberculosis had at last been discovered, the people and the profession felt that the millennium in medicine had come. For days and weeks the public press devoted a liberal space to telegraphic messages, editorials, and interviews with medical men relative to the new treatment. For months the medical journals in all countries rivaled each other in bringing the latest reports from

Berlin and other large medical centres in the way of telegrams, correspondence, editorials, and original contributions.

"The first announcement of the discovery brought thousands of patients and doctors to the German capital, the former to be cured of their tubercular disease, the latter to receive instruction and to make themselves proficient in all the details of the new treatment. No other event in the world's history ever attracted so much attention, and no discovery in medicine or surgery ever found such ready introduction and universal acceptation. The discoverer — the distinguished Koch, the father of bacteriology—had scored so many victories on this modern field of research that every word he uttered brought conviction. His views were promptly adopted by the most prominent physicians and surgeons in Germany and other countries, and the new treatment was applied everywhere, by the best men in the profession, as fast as the precious remedy could be obtained.

"Within a few weeks the most enthusiastic and encouraging reports came from scores of prominent clinics and large hospitals. Within a few months volumes have been written on this subject; several special works on this treatment left the press and were translated into many languages. A new journal, devoted exclusively to the treatment of tuberculosis with Koch's lymph, has come into existence and has a good subscription-list from the very start. It is true that some of the more conservative members of the profession were a little slow in accepting the new doctrine and practice; but the large majority followed the current set in motion by the great Koch and his many eminent admirers and devoted followers.

"It was not long, however, before the glowing accounts of the results of the new treatment of tuberculosis came at longer intervals and in a more moderate tone, and were interspersed with the reports of cases from different parts of the world in which it proved a complete failure, and not in an inconsiderable number of cases it was charged with having caused a speedy

fatal termination. Then came the timely warning of the veteran pathologist, Virchow, who showed, by numerous post-mortem examinations of patients who died under this treatment, that death was caused by dissemination of the disease from a local focus acted upon by the lymph. The evidences proving this source of danger have been rapidly accumulating, and contributed largely toward subduing the first enthusiasm and limiting the scope of administration of the remedy.

"The disastrous consequences which followed the use of the lymph, perhaps often injudiciously and recklessly applied, induced a number of medical societies to condemn its use, and led some of the local governments to restrain its further application by legal enactments.

"Enough time has now elapsed to judge of the merits of the treatment of tuberculosis by Koch's lymph, or, as it is now called, *tuberculin*. It has been put to test in the treatment of all forms of tuberculosis.

"Surgeons, physicians, gynæcologists, obstetricians, dermatologists, otologists, and ophthalmologists have given the new treatment a fair trial, and the accumulated experiences from all these sources have shown, beyond all doubt, that its indiscriminate use is attended by many immediate and remote dangers, and that most cases in which it appeared to prove beneficial at first have relapsed, and after weeks and months were no better, or even worse, than when the treatment was commenced.

"Men who first regarded the lymph as a specific in all forms of tuberculosis make this claim no longer. Many who were enthusiastic in their praise of what they observed from the use of the remedy in the beginning have now suspended its use. Hospitals and wards set aside for the special treatment of patients suffering from tuberculosis are now deserted. The market is overstocked with a supply of Koch's lymph and Koch's syringes. Not only the profession but the public has become aware that the claims made for the remedy only a few months ago are unfounded. It is left for Koch or some other investigator, in the

future, to discover a substance or agent which will answer the expectations that were at first entertained for the lymph.

"Koch's lymph has been a deceptive bubble which, for a short time, commanded the attention and admiration of the whole world, but which has been ruthlessly pricked by the critical scalpel in the hands of the father of modern pathology. The treatment of tuberculosis with Koch's lymph and the numerous substitutes which have recently been forced on the attention of the profession will soon be only a matter of history. My 'Away with Koch's Lymph!' is based upon my own observations made at the Milwaukee Hospital during the last four months' service in that institution prior to my removal to this city. The material is not large, but the careful observations made entitle me to give a positive opinion and warn others against further experimentation with this remedy.

"The lymph first used I received through the courtesy of Dr. J. S. Billings, of Washington, and when this was exhausted I received an abundant supply direct from Dr. Libbertz, through the influence of my distinguished friend, Professor von Esmarch. The tubercular nature of the lesions in all cases that came under my own care, if any doubt existed in this regard, was established by microscopical examination and search for the bacillus.

"TUBERCULOSIS OF JOINTS AND BONES.

"It has been claimed by a number of eminent surgeons that in the absence of caseous foci and sequestra tubercular joints are amenable to successful treatment by lymph injections, and that in a fair percentage of cases not only a cure can be effected, but a perfect functional result obtained. The same authorities also maintained that, in the event the disease had advanced to the formation of caseous deposits, or sequestration, the same treatment, by limiting the extension of the tubercular process, would place the parts in a more favorable condition for subsequent successful operative interference. Although my experience with Koch's lymph in this class of cases has been limited

to four cases, it has taught me that neither of these claims are well founded.

"*Case V. Synovial Tuberculosis of Knee-Joint; Intra-articular Injection of Iodoform Emulsion Followed by Koch's Treatment.*—Maria Gierswska, aged 18, born in Poland, housemaid, came under my care at the Milwaukee Hospital, January 11, 1891. No hereditary tendency to tuberculosis in the family. Patient is fairly well nourished, but somewhat anæmic. She has been a servant-girl for several years and was required to do a great deal of scrubbing, and to this part of her work she attributed a pain in the right knee-joint, which made its first appearance about two years ago. The pain was worse at night, but did not prevent her from following her occupation until six months ago. At that time she noticed that the joint was swollen and tender on pressure. The swelling increased rapidly in size and the movements of the joint became impaired. Examination of the joint revealed the presence of a copious effusion, with thickening of the capsule. No circumscribed points of tenderness over epiphysial extremities of the tibia and femur. Patient can walk without the aid of crutches.

"On January 12th the joint was aspirated and six ounces of synovial fluid, in which small fibrinous shreads were suspended, was removed, after which an intra-articular injection of a 10-per-cent. emulsion of iodoform in glycerin was made. The patient was allowed to use the limb. In the evening the temperature, which had been normal before the injection was made, rose to 102.8° F., but was again found normal the next day. At the end of forty-eight hours the joint was swollen as much as before the aspiration. On January 17th aspiration and injection were repeated. No decided improvement had taken place when the tuberculin treatment was commenced, January 22d. The highest temperature produced by the first injection was reached at the end of two hours. On the following day the swelling had increased, the capsule was tense, and the joint tender and much more painful than after the iodoform injections.

The injection of six milligrammes of tuberculin, made January 26th, was followed, at the end of twelve hours, by a temperature of 105.8° F.,—the highest temperature recorded in this case.

"The patient complained of headache and pain in the region of the stomach and spleen, attended by diarrhœa.

Number of Injections.	Date.	Dose in Milligrammes.	Temperature before Injection.	Temperature during Reaction.	Temperature after Reaction.	Pulse before and during Reaction.
1	Jan. 22	2	96.6	100.8	100	80 90
2	" 23	4	100	103	99	96 112
3	" 25	2	99	102.2	99	70 106
4	" 26	6	99	105.8	99	84 144
5	" 28	5	99	105	100.4	100 144
6	Feb. 3	6	98	105	99	82 140
7	" 5	2½	99	100.4	99.2	96 100
8	" 7	3	99	99.8	99	76 86
9	" 10	6	98.2	103	98	76 108
10	" 14	6	98	99	98	74 84
11	" 19	5	98	99.4	98.4	72 90
12	" 21	6	98.4	99.4	98.4	76 80
13	" 24	6	98.4	99.6	98	72 96

"The local and general reactions in this case were pronounced, but both subsided gradually during the treatment. While in the beginning of the treatment the temperature rose to nearly 106° F., the last injection of six milligrammes was followed by only a little more than one degree of rise in temperature. During the time the patient received this treatment she lost much in flesh, and became very anæmic. She left the hospital February 26th, and at that time the joint was not much swollen, and I confidently expected a permanent improvement. She returned in two weeks, when the effusion had returned to about the same extent as when the treatment was commenced. As I had lost faith in the Koch remedy in the treatment of this class of tuberculosis, I returned to the treatment by intra-articular injections of iodoform.

"*Case VI. Tuberculosis of Left Knee-Joint.*—William Gabl, 30 years of age, laborer, became an inmate of the Milwaukee

Hospital, March 9, 1891. No history of tuberculosis in his family. Had been in good health until nearly a year ago, when, without injury or any other apparent cause, he was taken with a pain in the left knee-joint, and in less than twelve hours it became enormously swollen and exceedingly painful. He was forced to abandon his work and seek rest, which in a few days brought about a marked improvement; the swelling disappeared almost completely, and the slight pain and soreness in the joint which then existed did not prevent him from following his occupation. From this time on, however, the knee was never entirely well, a number of slight attacks similar to the first occurring during the summer months. Since November he has been unable to work; the swelling remained permanently, being most marked at the upper recess of the synovial sac and on each side of the patella. The pain has never been severe when the limb is at rest, and until recently the patient has been able to walk without the aid of crutches.

"On admission, the patient was anæmic and had lost about twenty-five pounds in weight during his illness. A physical examination of the chest yielded a negative result; the left limb is atrophic; the swelling of the knee-joint, which is considerable, appears to be due entirely to thickening of the synovial membrane, there evidently being no effusion in the joint; patient can flex and extend leg nearly as well as the opposite one. The temperature was normal before the first injection was given, but within six hours the thermometer registered 104.7° F. in the axilla.

Number of Injections.	Date.	Dose in Milligrammes.	Temperature before Injection.	Temperature during Reaction.	Temperature after Reaction.	Pulse before and during Reaction.
1	Mar. 9	2	98.4	104.7	98.2	81 108
2	" 12	2	98.2	101.8	98.4	78 96
3	" 16	2	99	102.3	98	66 84
4	" 21	2	97.8	99.6	97.8	72 90
5	" 25	2	99	99.9	99	76 80

"The local reaction was prompt after every injection, consisting of increased swelling, pain, and tenderness. After the fourth injection the physical signs pointed to the existence of a moderate effusion in the joint. During the febrile reaction the patient suffered always more or less from headache, backache, and pain in the region of the spleen. As the general reaction appeared to have nearly ceased after the fifth injection, the Koch treatment was suspended to ascertain its ultimate effect upon the local lesions. As, a week later, no perceptible improvement had taken place, the joint was aspirated and about three ounces of a synovial fluid, in which minute fibrinous flocculi were suspended, removed, and an ounce of a 10-per-cent. iodoform emulsion injected. The Bruns treatment is being continued with a fair prospect of an ultimate recovery.

"*Case VII. Tuberculosis of the Hip-Joint.*—Maggie McDermott, aged 15, was admitted to the Milwaukee Hospital, February 28, 1891, to be treated for an affection of the left hip-joint. Her father died of pulmonary tuberculosis five years ago. With the exception of the usual diseases incident to childhood, the patient considered herself in good health until a year ago, when she was taken with a pain in the region of the left hip-joint. From that time on she has walked with a decided limp, but continued her work as a servant-girl until a few months ago. The pain was always worse at night and after undergoing unusual exertion. The greatest pain is referred to the region in front of the hip-joint, but at times she complains also of a pain about the inner aspect of the knee-joint on the same side. Her general health is not much impaired.

"An examination of the hip-joint reveals all the characteristic signs and symptoms of tubercular synovitis following a primary focus in the neck of the femur. Extension was made by weight and pulley; at the same time she was subjected to Koch's treatment, with results shown in the accompanying table:—

Number of Injections.	Date.	Dose in Milligrammes.	Temperature before Injection.	Temperature during Reaction.	Temperature after Reaction.	Pulse before and during Reaction.
1	Mar. 2	2	99	100.1	98	78 92
2	" 5	4	98	103 3	99.6	80 102
3	" 12	4	99	103.5	100.4	90 112
4	" 16	4	98.4	100.6	99	84 100
5	" 21	4	99	101	98.4	84 92
6	" 23	4	97.4	99.4	99.6	80 108
7	Apr. 3	4	98.2	100	99 4	92 104
8	" 6	4	98	100	98.2	94 100

"The injections until toward the last always were followed by an aggravation of the local symptoms, which usually lasted until the end of twenty-four or thirty-six hours. Rest in bed and extension had a prompt effect in diminishing the pain and tenderness, but the tuberculin injections appeared to have no influence in arresting the progress of the disease, and had to be abandoned, as the patient's general condition had undergone a decided change for the worse since their use had been commenced.

"OTITIS MEDIA TUBERCULOSA.

"*Case VIII. Pulmonary and Laryngeal Tuberculosis; Tuberculosis of Middle Ear on Both Sides, and of the Mastoid Process on the Right Side.*—Charles W. Mueller, aged 35, German, farmer by occupation, came under my care at the Milwaukee Hospital, December 10, 1890. Tuberculosis is hereditary in his family, and he gives a history of pulmonary tuberculosis dating back for a year and a half. About six months ago he became hoarse, a symptom which gradually increased in severity until he came to the hospital, when his voice was a mere whisper. Two months later his ears became affected, the first indication of this trouble being a roaring, buzzing noise, attended by slight pain and followed by increasing deafness. The patient is considerably emaciated, but his appetite and digestion have been good. Examination of the chest reveals extensive infiltration of the right apex of the lung, with a number of small cavities. The laryngoscope shows numerous nodules at the

base of the epiglottis and upon the vocal cords, œdematous infiltration, and at some points minute foci of caseation and ulceration; drum of the ear on both sides perforated and covered with fungous granulations; on the right side over the mastoid process, and a considerable distance above and behind it, the skin is reddened and undermined by an extensive abscess.

"The abscess was incised and its interior, which was lined with a thick layer of granulation tissue, was scraped out with a sharp spoon, and after thorough irrigation was tamponed with iodoform gauze. Almost the entire external surface of the mastoid process was denuded of periosteum. Granulations taken from the interior of the abscess and from the external ear, examined under the microscope, contained numerous tubercle bacilli. The external ear on both sides was disinfected, iodoformized, and loosely packed with absorbent cotton. Under this treatment some improvement was noticeable until the tuberculin treatment was initiated. This patient received the first dose of Koch's lymph administered in the Milwaukee Hospital. Gradually increasing doses were given until the maximum dose, 25 milligrammes, was reached, as both the local and general reactions were not well marked. As soon as the dose exceeded 10 milligrammes a diarrhœa set in which it was found difficult to control, and which greatly reduced the strength of the patient.

Number of Injections.	Date.	Dose in Milligrammes.	Temperature before Reaction.	Temperature during Reaction.	Temperature after Reaction.	Pulse before and during Reaction.
1	Jan. 21	2	99	102.2	98.6	84 96
2	" 23	4	98	101	99	80 100
3	" 25	6	98	100.8	98.4	94 100
4	" 27	10	98	102	99.2	86 106
5	" 29	15	97.2	102.6	98	82 98
6	Feb. 2	18	98.7	101.4	98.2	86 90
7	" 5	20	98.4	102 8	98.8	82 94
8	" 7	20	99.3	100 6	99.2	88 104
9	" 9	25	98.6	102.2	98.4	84 102

"During this treatment the patient lost his appetite, which, in addition to the exhausting diarrhœa, contributed largely to the rapid loss of flesh and strength. He left the hospital

March 12th, and died a few weeks later. I have no doubt that the lymph treatment shortened his life a number of weeks, and perhaps months.

"*Results of Tuberculin Treatment in Forty-three Cases of Pulmonary Phthisis.*—The injections were made, as a rule, every other day, in order to ascertain the full extent of the local and general reaction following each dose of tuberculin. The first dose never exceeded 1 milligramme, and in grave cases the treatment was commenced with one-half of this quantity. The dose was never increased if the temperature during the reaction following it rose to 101° F., and if this result was reached in many cases the dose was diminished or the interval between the injections increased. It is therefore probable that in grave cases the unfavorable symptoms following the injections were not so much due to the action of the tuberculin as to the intrinsic tendencies of the disease to aggravation. It is, however, an entirely different matter in the mild cases, in which, in spite of a careful increase of the dose, the local and general symptoms underwent a rapid change for the worse, as in such cases the unfavorable results must be attributed to the action of the tuberculin, and not to the intrinsic tendencies of the disease. The whole number of cases treated by tuberculin injections at the Milwaukee Hospital during the months of January, February, March, and April is forty-three,—thirty-two males and eleven females. For the sake of convenience, these can be divided into mild, medium, and grave cases.

Mild cases, 8 males and 4 females,	12
Medium cases, 10 males and 2 females,	12
Advanced cases, 14 males and 5 females,	19
	43
Died in the hospital, 1 male and 1 female,	2
Aggravation of all the symptoms during treatment:—	
14 males and 8 females,	22
No improvement, 5 males and 1 female,	6
Improved, 10 males and 1 female,	11
Apparently cured, 2 males,	2
Died,	2
	43

Died soon after leaving the hospital:—	
4 males and 2 females, ...	6
Of the mild cases unfavorably affected by the treatment:—	
1 male and 3 females, ...	4
Of the mild cases improved, 4 males and 1 female, . .	5
Of the mild cases apparently cured, 2 males, . . .	2
	11

"The two cases that were apparently cured belonged to the mild type of the disease; no such result was obtained in any of the thirty-one cases belonging to the medium or advanced form of the disease. In one of the cases that was apparently cured the sputum contained no bacilli, and in the other there was no expectoration; consequently, some doubt must remain as to the tubercular nature of the pulmonary affection.

"In the cases of medium gravity the result of the treatment was as follows:—

Aggravated, ...	5
Not improved, ...	2
Improved, ...	5
	12

In the grave cases the treatment was followed by serious results in	12
By no improvement in	3
By temporary improvement in	2
By death in	2
	19

"GENERAL REMARKS ON TUBERCULIN TREATMENT.

"*Diagnostic Value of Tuberculin.*—Great diversity of opinion prevailed for a long time as to the diagnostic value of tuberculin. The first reports of the use of this substance were unanimous in attributing to it positive diagnostic value. It was claimed that reaction only occurred in tubercular patients by the specific action of the lymph on tubercular tissue, and that the absence of increase of temperature after injection of the lymph decided the non-tubercular nature of the affection.

"Leyden, Quincke, Ebstein, Weber, and Biermer maintained that the absence or presence of reaction after the use of

tuberculin must not be regarded as absolute proof of the existence or non-existence of tubercular disease in all cases.

"Schultze, Finkler, Guttmann, Schreiber, Lichtheim, and Rumpf had great faith in the diagnostic value of the use of tuberculin in tuberculosis of the internal organs. The same discrepancy of opinion existed among surgeons as to the value of tuberculin injections in the differential diagnosis of surgical tubercular and non-tubercular lesions.

"Bergmann relied on the reaction following the use of tuberculin in differentiating between tuberculosis on the one hand and syphilis and carcinoma on the other. Bardeleben and Köhler were reserved in their verdict as to the diagnostic value of the method.

"Trendelenberg regarded the febrile reaction following an injection of tuberculin as an evidence of the tubercular nature of the lesion, except in tuberculosis of the testicle. Esmarch was of the opinion that in doubtful cases the reaction following the use of the remedy is of great diagnostic value. Bramann and Mikulicz placed great confidence in the presence or absence of reaction. König and Hildebrand have observed reactions in lesions resembling in appearance tubercular affections, but which, by other diagnostic aids, were shown not to be of a tubercular nature. Clinical experience has demonstrated that general reaction is produced by tuberculin in cases of actinomycosis and in certain forms of sarcomatous tumors, and that, consequently, this method of diagnosis cannot be relied upon in differentiating between tubercular lesions and these affections.

"A number of cases reported in this paper furnish conclusive proof that the susceptibility to general reaction varies greatly in different tubercular individuals. In some intense reaction followed the use of small doses when the tubercular lesion was limited; in others suffering from extensive tuberculosis large doses produced no rise in temperature. That in the latter class of cases the affection was of a tubercular nature there could be no doubt from the history of the cases, the

appearance and location of lesions, and the subsequent behavior of the affection; and in some of the cases the presence of tubercle bacilli in the affected tissue was demonstrated.

"I look upon the local reaction in affections of the lymphatic glands as a valuable diagnostic aid in differentiating, by the use of Koch's lymph, between tubercular and non-tubercular affections of these organs. If the enlargement of the lymphatic glands is due to a tubercular affection, the existing swellings not only become larger, more painful and tender a few hours after the injection of a dose of the lymph, but other glands that could not be felt before the injection become enlarged, and can be felt in the vicinity of those that were recognized before the use of the remedy. But even in such cases I regard inoculation experiments of greater diagnostic value than injections of tuberculin, yielding more positive results without exposing the patient to the risks of local and metastatic dissemination of the disease incident to the latter procedure.

"If patients suffering from non-tubercular affections will occasionally, only, respond to the tuberculin test on the one hand, and on the other, in exceptional cases, individuals suffering from well-marked typical tubercular affections have proved themselves refractory to the action of the tuberculin, it must appear evident that the use of this substance cannot be relied upon in making a positive differential diagnosis between tubercular and non-tubercular affections. If it can be shown, at the same time, that a single injection of tuberculin is not devoid of danger, and that implantation of the product of this disease in guinea-pigs in the course of three or four weeks will yield results which will enable us to make a reliable diagnosis between tubercular and non-tubercular affections, it is apparent that the use of Koch's lymph as a diagnostic resource should be discarded, or, at least, limited to exceptional cases.

"*Therapeutic Value of Tuberculin.*—It is now generally conceded that many cases of tuberculosis reported as cured have since relapsed; some of these have died, and others have been

subjected to different treatment. In many instances, of course, the original report has not been supplemented by subsequent communication; as an absolute diagnosis, even by the use of Koch's lymph, is not always possible. It may be some of the alleged cures rest on a faulty diagnosis. This applies with special force to the two cases of pulmonary disease reported as cured in this paper.

"Again, it must not be forgotten that tubercular affections not infrequently, under favorable local or general conditions or improved dietetic, hygienic or climatic changes, undergo a spontaneous cure; so that for nearly all methods of treatment, so far suggested, similar exceptional results can be claimed. In not a single instance of the eleven cases of surgical tuberculosis that came under my own observation did the treatment result in anything more than a temporary improvement, and in several of them it was followed by local extension of the disease and serious impairment of the general health. The effect of tuberculin proved more serious in the treatment of the forty-three cases of pulmonary tuberculosis. There can be but little doubt that in a number of the fatal cases, death was hastened by the treatment, and that in a number of the mild cases it contributed largely toward the rapid local extension of the lesion; while the tuberculin treatment of pulmonary tuberculosis can show no better results, it is difficult to ignore the fact that it has been productive of more harm than almost any other plan of treatment heretofore suggested, and on this score alone the verdict 'Away with Koch's Lymph!' is timely and imperative.

"*Dangers Attending the Use of Tuberculin.*—Tuberculin, when brought in contact with tubercular tissue, produces coagulation necrosis, and during this process a toxic chemical substance is produced, which, when it reaches the general circulation, causes the febrile reaction. The time necessary to reach this stage of its action is usually from three to six hours. The intensity of the reaction depends on the quantity of the toxic substance that is produced and finds its way into the general

circulation. The general reaction is a septic condition of the organism produced by the toxic substance resulting from the action of the tuberculin on the tubercular tissue. The temperature and the other general symptoms continue until this toxic substance is eliminated through one or more of the excretory organs. The immediate danger attending the tuberculin treatment consists in the production and introduction into the circulation of a fatal dose of this toxic substance. That the fear of a fatal sepsis resulting from the action of Koch's lymph is not unfounded is shown by a number of such cases that have been reported. If the whole truth were known, this number would be greatly increased by unpublished cases.

"The more remote dangers attending the tuberculin treatment have been pointed out by Virchow. The destructive effect of the tuberculin on the granulation tissue breaks down the wall surrounding the infected area and liberates the bacilli and their spores,—an occurrence which can hardly fail in giving rise to local and general dissemination. The granulation tissue, the specific primary product of tubercular inflammation, is the wall of defense built up by the tissues to protect the adjacent parts and the organism against invasion. Any method of treatment which interferes with this manner of defense clears the way for the enemy and secures victory for the invading army. If future research should lead to the discovery of a specific remedy for the cure of tuberculosis, it will be an antagonistic microbe to the bacillus of tuberculosis, or a substance which, when brought in contact with a tubercular focus, will have an opposite effect on the tissues from that of Koch's lymph.

"I have given Koch's lymph a fair trial and have carefully observed its effects, and have become firmly convinced both of the danger which attends its use and its utter inutility in curing any form of tuberculosis."

This chapter has been written for the special purpose of placing myself on record as one who protests earnestly against further experimentation with this mysterious and dangerous

fluid. A careful study of the voluminous literature on the use of Koch's lymph and my own experience with it have induced me to abandon the use of Koch's lymph both as a diagnostic and therapeutic agent.

Professor Klebs, of Zurich, has recently brought to the attention of the profession a purified preparation of Koch's lymph, which he calls *tuberculocidin*. In a letter which the author recently received from him he claims that the toxic substances which made Koch's lymph so dangerous have been eliminated, while the therapeutic value has not been diminished by the chemical processes to which the crude lymph was subjected. He is enthusiastic in his expectations of the curative power of this new preparation, but I am free to confess that I am not inclined to give this or any other specific remedy for tuberculosis further trial until their therapeutic value has been fully established by experimental research.

CHAPTER XXIII.

Treatment of Tuberculosis of Joints by Parenchymatous and Intra-articular Injections.

The successful treatment, in some cases of bone and joint tuberculosis, by parenchymatous and intra-articular injections is one of the important achievements of modern surgery. Attempts in this direction were made long before the bacillus of tuberculosis was discovered, and before the true pathology of tubercular inflammation was understood. It is, however, since the true nature of the tubercular process has been revealed, and since the antibacterial action of a number of antiseptic substances has been carefully studied experimentally and clinically, that this method of treatment has been placed upon a scientific basis and has yielded satisfactory results. It is reasonable to assume that if, by a harmless procedure, safe and efficient chemical substances can be brought in contact with the affected tissues within diseased bones and joints that exercise a direct curative effect, it would constitute a decided improvement over former methods of treatment by internal administration or external application of the same remedies. The remedies which have been used for this purpose possess potent antiseptic and stimulating properties, and have been employed with a view to destroy the microbic cause of the disease, and to aid and expedite the process of repair.

The first attempts at intra-articular medication were made with a Pravaz syringe, the solution being thrown into the joint without previous evacuation of its fluid contents. At the present time the joint is punctured with a larger instrument, and if it contain fluid this is evacuated before the injection is made. If the joint contain tubercular pus, the intra-articular injection is preceded by irrigation of the joint with a mild antiseptic solution. The best instrument for puncturing a joint is a small trocar, through the cannula of which the joint can be emptied,

irrigated, and injected. The puncture is to be made under strictest antiseptic precautions, and in accordance with the rules laid down elsewhere. In tubercular empyema of a joint, irrigation should never be neglected as a preliminary step to the intra-articular injection. The simplest method of irrigating a joint is to connect the cannula with a rubber tube attached to an irrigator holding the antiseptic solution. A 2-per-cent. solution of boric acid or a one-third of 1-per-cent. solution of salicylic acid in sterilized water should be used for this purpose. The connection between cannula and rubber tube should only be made after the surgeon has been satisfied that neither of them contains atmospheric air. By elevating the irrigator the fluid enters the joint, and the infusion should be continued until the capsule is thoroughly distended, when the rubber tube is detached and the fluid evacuated through the cannula by compressing the joint. This procedure is repeated until the fluid returns perfectly clear. The intra-articular injection is made with an ordinary one-ounce glass syringe, to the nozzle of which a piece of aseptic rubber tubing is attached, which is fastened to the end of the cannula with the same care as in making the irrigation. The quantity of fluid which is to be injected should never be large enough to cause painful distension. After the cannula is withdrawn the puncture should be sealed with a pledget of aseptic cotton and collodium.

Among the many substances which have been used for parenchymatous and intra-articular medication, I will only make mention of such that have received the most attention, and which experience has shown to be of some value.

Tincture of Iodine.—This preparation of iodine, pure or diluted with a solution of potassic iodide, was one of the first substances employed for intra-articular medication. The late Professor Brainard, of Chicago, made extensive use of it in the treatment of chronic hydrops of joints. Usually the injection was made through the cannula of a trocar after the joint had been emptied of its contents. The violent local and general

reaction which sometimes followed the injection was in the way of a more general adoption of this method of treating diseased joints. It has yielded satisfactory results in the treatment of catarrhal synovitis, as the vasomotor irritation which the iodine produces upon the inner surface of the cavity of the joint and the vascular changes connected with it bring about speedy retrograde metamorphosis of the inflammatory product and hasten the process of absorption. It is never safe, even in such cases, to allow the tincture to remain in the joint, as the desired therapeutic effect can be obtained by injecting through the cannula of the trocar from 2 to 4 drachms of the tincture, and, after bringing it in contact with the entire surface of the joint by flexion and extension, friction and compression allow it to escape.

In the treatment of tubercular joints this remedy has not only proved a failure, but has often been followed by aggravation of the local conditions, and should be stricken from the list of therapeutic resources in the treatment of these affections.

Carbolic Acid.—Soon after carbolic acid was introduced into surgical practice as an antiseptic agent, it was also employed in the treatment of chronic inflammation of joints as an intra-articular injection. Hueter* resorted to parenchymatous and intra-articular injections of a 2- to 3-per-cent. solution of carbolic acid in the treatment of chronic inflammation of bones and joints, upon the supposition that the carbolic acid, when brought in direct contact with the diseased tissues, would destroy the microbic cause of the inflammation. The injections were made with a Pravaz syringe every other day. In a case of osteomyelitis granulosa hyperplastica, the favorable effect of the injections became apparent soon after the treatment was commenced. Twenty injections, in the course of five weeks, resulted in a permanent cure.

Hueter's treatment was quite generally adopted in Germany,

* "Die Wirkungen der parenchymatösen Carbolinjectionen bei Entzündungen der Gelenke und Knochen." Deutsche Zeitschrift f. Chirurgie, B. iv, p. 526; B. v, p. 120.

but the results, on the whole, were so unsatisfactory that it was soon abandoned. The results have not been more encouraging by puncture and irrigation of the joint with solutions of carbolic acid, and at the present time carbolic acid has been given up almost completely as an antitubercular remedy. The same fate has met the following two substances:—

Arsenious Acid.—Cavagnis,* of Venice, made a number of experiments on rabbits and guinea-pigs to determine the therapeutic value of arsenic in the treatment of tuberculosis.

On April 17, 1881, four rabbits, two gray and two black, weighing, respectively, 1580, 1590, 1660, and 1680 grammes, and four guinea-pigs, weighing 370, 500, 510, and 610 grammes, were inoculated with tubercular material by subcutaneous injection. From the date of inoculation until May 28th, the gray rabbits received 1 drop of Fowler's solution, diluted with distilled water, daily; the medicine was injected into the back part of the mouth with a Pravaz syringe; the black rabbits were given 2 drops daily in the same manner, while the guinea-pigs received only half a drop. The smallest guinea-pig was killed May 21st, all the other animals June 6th. One of the rabbits and all of the guinea-pigs were tubercular. A tubercular ulcer at the point of inoculation had developed, the tissues of which contained numerous bacilli; cheesy foci in the vicinity of the ulcer; lumbar and prehepatic glands enlarged and partly cheesy; spleen enlarged, containing numerous tubercles; liver also the seat of tuberculosis. One of the guinea-pigs had nine small tubercles in the lungs.

The other three rabbits presented an encapsulated abscess at site of inoculation, and one or two small, cheesy masses in the vicinity, but aside from this no evidence of tuberculosis could be detected. Inoculations made with the contents of the abscesses yielded negative results.

Landerer used this substance dissolved in distilled water in the proportion of 1 to 1000, and of this he injected from one to

* Etudes de la Tuberculose, p. 462.

two syringefuls at intervals of a few days into the affected joint. The results must have been decidedly unfavorable, as it does not appear that this remedy was used for the same purpose by others.

Corrosive Sublimate.—Next to carbolic acid corrosive sublimate has been used more extensively as an antiseptic in the treatment of wounds than any other substance, but has never been popular as an antitubercular remedy. Experiments made by Cavagnis* to test its antibacillary action yielded very favorable results as far as its action is concerned in preventing the growth of tubercle bacilli in the tissues of the rabbits.

On April 17, 1887, he inoculated three rabbits and three guinea-pigs with tubercular material, and subjected these animals at once to a thorough treatment with corrosive sublimate, which was administered in doses of 4 drops of a solution of 1 to 100 of distilled water, while the guinea-pigs received only one-fourth of this quantity. May 1st, one rabbit died; another May 10th; the animals were very much emaciated, and the necropsy revealed a small mass of cheesy appearance at the point of injection; no bacilli could be found in the caseous material, and the internal organs showed no trace of tuberculosis. The third rabbit became so emaciated that treatment was suspended May 10th, and ten days later the animal died. A large abscess containing non-tubercular pus was found where the injection was made. Internal organs and lymphatic glands healthy. The guinea-pigs were killed June 7th. These animals presented a tubercular ulcer at the site of injection; extensive tuberculosis of the lymphatic glands, spleen, and liver.

Vogt injected from three to five syringefuls of the following solution into tubercular joints: Corrosive sublimate, 0.1; sodic chloride, 1.0; distilled water, 50.0. Evidently without success, as Vogt himself soon suspended its use.

Another remedy that seems to have been used only by the one who suggested it and a few others is

* Op. cit.

Phosphate of Lime.—Kolischer* used an acidulated solution of phosphate of lime for parenchymatous and intra-articular injections in tuberculosis of bones and joints. The injections were made with an ordinary Pravaz syringe. Pain and other symptoms of local reaction always followed the injection and continued for five to six days, after which the limb was immobilized. After this the swelling diminished in size and the tissues became firmer, showing that healing by cicatrization was progressing in a satisfactory manner.

E. Freund† gives full directions for the preparation of the solution and gauze of acid phosphate of lime.

In another publication Kolischer‡ reports five hundred cases treated by his method, and admits that, while tubercular joint affections were benefited by the treatment, it had no such influence in cases of central foci in bone and the sequestrating form of bone tuberculosis. This treatment was faithfully tried in the Klinik at Tübingen, but with negative results, as we learn from the paper published by E. Müller.§ It is not probable that the use of this remedy will be revived in the future in the treatment of tubercular affections of bones and joints.

Chloride of Zinc.—Lannelongue made an important contribution to the Academy of Medicine of Paris, concerning the local treatment of tuberculosis by injections of solutions of chloride of zinc. His attention was called to this remedy during the treatment of a case of lymphangioma. He noticed that one of its effects was its power of changing softened tissues into hard fibrous structures. During the last few months he treated twenty cases of surgical tuberculosis by parenchymatous injections of a solution of chloride of zinc. The injection is made into the periphery of the tubercular lesions, so as to stim-

* "Ein neues Heilverfahren bei lokalisirten Tuberculösen Processen." Wiener Med. Presse, B. xxviii, No 22, 1887.

† "Ueber die bei Kalkbehandlung der localtuberculose zur Verwendung gelangender Lösungen." Wiener Med. Presse, B. xxviii, No. 24, 1887.

‡ "Erfahrungen über die Kalkbehandlung bei Localtuberkulose." Wiener Med. Presse, B. xxvii, No. 29.

§ "Ueber die Kalkbehandlung der localisirten tuberculösen Processe." Centralblatt f. Chirurgie, No. 15, 1888.

ulate the surrounding healthy tissue to active proliferation, by which the focus is encapsulated. For tubercular disease of the knee four or five injections are usually made around the circumference of the superior *cul-de-sac*. From 8 to 10 drops of the solution (10 per cent.) suffice for the knee of a child aged 10. He claims excellent results in the treatment of tuberculosis of the lymphatic glands, and reports a few joint cases similarly benefited.

Balsam of Peru.—More than thirty years ago, Sayre employed balsam of Peru in dressing wounds after resection of joints for tubercular affections. The results following his operations were much better than the average in the hands of other surgeons at that time, and we must attribute them, at least in part, to the use of this substance as a wound-dressing.

Quite recently Landerer* has again called attention to the utility of the action of this antiseptic in arresting tubercular inflammation. As the result of his experiments on animals and from clinical experience with this remedy, he has come to the conclusion that its therapeutic action is owing to its stimulating effect on the tissues, which brings the parts in such a condition as to render the pathogenic action of tubercle bacilli harmless. He ascertained, by his experiments on rabbits that had been rendered tubercular by inoculation, that the disease was favorably influenced by innocuous injections of an alkaline emulsion of this drug. In the treatment of fistulæ and deep-seated tubercular processes he uses a solution of the balsam in sulphuric ether 1 to 5 for injection.

For parenchymatous injections he employs an emulsion of the strength of 1 to 4 composed of oil of sweet almonds and a .07-per-cent. solution of sodic chloride.

He reports twenty-five cases of tuberculosis of bone, generally implicating joints, greatly improved by injections of an emulsion of balsam of Peru combined in some cases with minor

* "Eine neue Behandlungsweise tuberculöser Processe." Münch. Med. Wochenschrift, No. 40, 1888.

operative procedures, and in some of these cases the joint affections were so serious that amputation was proposed, but the operation was refused by the patients.

Vámossy * has made extensive use of gauze prepared with balsam of Peru in the treatment of open wounds after the removal of tubercular products with signal success. He reports twenty-eight cases treated according to Landerer's method, and expresses himself as satisfied with the results. Among these cases he observed albuminuria three times, cystitis twice, and acute nephritis once,—affections of the genito-urinary organs which he believes were cured by the balsam.

Binz † also calls attention to the irritating effect of this drug on the urinary apparatus.

Landerer thinks the danger in the use of the balsam has been greatly overestimated, and that it can be avoided by proper care in its use. Although balsam of Peru does not appear to possess any direct antibacillary properties, there can be no doubt that it can be applied with great benefit in the treatment of tuberculosis of bones and joints, especially after fistulous openings and open ulcerating surfaces have formed, as well as a dressing after resection of joints and the treatment of tubercular abscesses by incision and curetting.

Camphorated Naphthol.—Camphorated naphthol was first prepared by Désesquelle, in 1888, and was first used in the surgical service of Pércer, at the Hôpital Lariboisière. It is a liquid prepared by taking β-naphthol 100 grammes, camphor 200 grammes, pulverizing each substance finely, gently heating the mixture until complete fusion; filter and preserve the liquid obtained in yellow-glass bottles, well corked. It possesses valuable antiseptic properties, and is strongly recommended by Reboul ‡ in the treatment of tuberculosis of bones and joints.

* "Zur Therapie der Localtuberculose mit Perubalsam." Wiener Med. Presse, B. xxx, Nos. 17–20, 1889.

† "Ueber den Perubalsam." Centralblatt f. klin. Medicin., B. x, 1889.

‡ "Contribution a l'étude du Traitement de la tuberculose des os, des articulations et des Synovialis tendineuses de l'emploi du Naphthol Camphré." Etudes experimentales et cliniques sur la Tuberculose, Paris, 1888–90, p. 608.

He believes that in the local treatment of these affections the employment of potent antiseptic remedies is indicated, and such substances should be selected which, of equal therapeutic value, are non-toxic, so that they can be used freely and for a long time. According to his estimation camphorated naphthol fills these two conditions, being only slightly toxic, an efficient antiseptic, and destructive to the tubercle bacillus. As naphthol camphor dissolves iodine, the following mixture can be used:—

Naphthol camphor,	90.0
Iodine,	10.0

The antiseptic properties of camphor naphthol have been demonstrated experimentally by Maximowitch, Park, Burrel, and Edington, and corroborated by the clinical results of Nicaisé, Fernet, Schwartz, Peyrot, Reboul, and others. The successful treatment of local tubercular foci by camphor naphthol has been established by the results obtained; but the action of this drug seems to be general as well, since the naphthol is absorbed and has been found, in a free state, in the urine of persons dressed with camphorated naphthol (Désesquelle).

If a wound, after operations for tubercular affections, is dressed with camphorated naphthol the urine shows the presence of naphthol for eight days, showing that its local and general action is prolonged, and may prevent relapses, secondary inoculations,—complications following so frequently operations for local tuberculosis.

Périer and Reboul have employed camphorated naphthol extensively as an injection, in doses varying from 50 to 100 grammes, in the treatment of articular tuberculosis and tubercular abscesses, with favorable results. The injections did not produce pain, and were never followed by violent local reaction or symptoms of intoxication.

Parenchymatous injections made with an ordinary Pravaz syringe proved equally successful in the different forms of local tuberculosis. The injections were repeated every eight days.

Reboul reports a large number of cases of tuberculosis of

bones and joints treated by incision, scraping and injections, and dressings of naphthol camphor, in which the results were all that could be desired,—speedy healing of the wounds and freedom from relapse. In a number of cases of spina ventosa, puncture and parenchymatous injections of camphor naphthol, repeated weekly, resulted in a permanent cure within three months. He believes that the curative effect of camphor naphthol, like other antitubercular remedies, when applied locally, consists mainly in the production of an irritative ostitis, and supports this opinion by citing the case of a patient treated for a tubercular lesion of the great trochanter with camphorated naphthol, who died of pulmonary tuberculosis. Around the tubercular focus which had been treated the bone presented the characteristic appearances of plastic osteomyelitis, and no bacilli or miliary tubercles could be found. The action of the remedy substitutes for the tubercular a plastic osteomyelitis.

Reboul has great faith in the conscientious use of camphor naphthol as a local application and dressing, in resection of tubercular joints, in securing an aseptic healing of the wound and guarding against local relapses and general miliary tuberculosis. He cites a number of operations of this kind on the larger joints in which this remedy was relied upon exclusively as an antiseptic, and the results certainly appear to corroborate the claims made for it.

He has also been satisfied with the results of interstitial injections with camphor naphthol in the treatment of fungous disease of joints.

Iodoform.—Injections of iodoform in the treatment of tuberculosis of bones and joints and tubercular abscesses were advised by Billroth and Mikulicz* ten years ago, and the latter published another paper on this subject a year later;† but it was not until a few years later that it came into more general use, through the teachings and writings of Mosetig von Moorhof.‡

* Berliner klin. Wochenschrift, 1881.

† "Die Verwendung des Iodoforms in der Chirurgie." Archiv f. klinische Chirurgie, B. xvii, p. 3, 1882.

‡ "Zur Iodoformfrage." Weiner Medicinische Blätter, B. viii, Nos. 10-12, 1885.

Mazzoni* believes that iodol-ether-glycerin injections into the tissues or joints has a favorable effect on tubercular lesions not only in arresting the disease, but also in expediting the subsequent reparative process.

At the present time the antitubercular action of iodoform is generally recognized from a clinical stand-point, but the results obtained by different experimenters on the lower animals concerning the same questions are at variance.

Experimental Studies.—Troje and Tangl,† to test the antibacillary action of iodoform, devised the following series of experiments: Iodoform vapor and powder were allowed to act on pure cultures; the powder was dusted on the culture medium in the neighborhood of cultures, and the vapor was allowed to accumulate in the culture chamber; animals were then inoculated with the growth and a series of "controls" was made. The vapor killed the bacilli only after fifty days, but then suppuration was produced by the action of chemical products, as pointed out by Koch. After the vapor had acted six days, however, the rapidity of the growth of the bacillus was diminished, whilst it had quite ceased at the end of four weeks, and the bacilli at this stage were distinctly weakened. When strewed on the culture the drug so diminished the virulence of the bacillus that after sixteen days nothing but cold abscesses were formed after inoculation, many giant-cells being present, and the course of the disease was very chronic. When mixed in the proportion of one part of the active culture to fifteen parts of iodoform, it was found that the bacilli were not always killed in fourteen days, although in one case they were quite innocuous at the end of eight days; at the end of three weeks they were dead, or at any rate harmless. The authors found also that they could obtain bacilli which would set up only chronic tubercle by means of the action of the iodoform out-

* "Ueber die Amwendung des Iodols in der chirurgischen Praxis." Berliner klin. Wochenscrift, No. 41, 1886.

† Berliner klin. Wochenschrift, No. 20, 1891. Supplement to British Med. Journal, July 18, 1891.

side the body, for when inoculating tubercle bacilli so treated they obtained a disease which was identical with *Perlsucht*, both in its clinical and pathological characters. Mixed with olive-oil or glycerin, in proportions of one part of iodoform to ten of the vehicle, they found that the organism was killed in sixteen days, the oil and the iodoform being much more efficacious than the glycerin mixture. Virulent bacilli can grow in the tissues, whatever iodoform mixture be introduced along with them, this being due to the fact that the tissues are such a good medium for the growth of the organism that the energy of the latter becomes very great, and the iodoform can exert little action on its growth; although outside the body, where the conditions for growth are not so favorable, the iodoform has a decided inhibitory effect. In the case of cold abscesses the growth of the bacillus is not so active, and therefore the iodoform has a better chance of exerting its valuable therapeutic properties. The authors found that the iodoform must act directly on the bacilli, as they have been able to demonstrate that it has a deleterious irritant action on the tissues; they also find that the action is most satisfactory in those cases where the number of bacilli is comparatively small, in which case the iodoform appears to prevent the growth of the bacilli. Their investigations have led them to the practical conclusion that iodoform is a true disinfecting agent as far as the tubercle bacillus is concerned; that it has a direct destructive effect upon the bacillus if left sufficiently long in contact. They have also shown that this drug diminishes the virulence of the tubercle bacillus, and that cultures thus treated produce a more benign form of tuberculosis in animals.

Gosselin* made a series of experiments on animals with mercurial preparations and iodoform, in order to ascertain if any of these substances could so alter the tissues as to render

* "Sur l'attenuation du virus de la tuberculose." Etudes sur la tuberculose, 1er Juillet, 1887.

them unfit as a soil for the tubercle bacillus. He reasoned that if such a condition could be brought about by the introduction of chemical substances otherwise harmless, an existing tubercular focus would be harmless, as local and general dissemination could no longer occur. Experiments with mercuric bichloride and biniodide had no effect in this direction. On the other hand, these mercurial salts appeared to aggravate the tubercular process. Iodoform yielded better results. It was administered, like the salts of mercury, subcutaneously. It was his intention to render the animals refractory to the tubercle bacillus by saturating the tissues with iodoform prior to the inoculation. He used a solution of iodoform of 10 to 100. Six rabbits were selected, three of which were subjected to iodoform treatment, while the remaining three were not thus treated, but kept under exactly similar conditions. Three drops of the ethereal solution of iodoform were injected under the skin every day for two months. In the beginning the iodoform was badly borne, as it diminished the appetite and caused frequent attacks of diarrhœa, and the animals cowered in a corner of a cage and showed no inclination to move about. These symptoms always disappeared with the suspension of the injections. After a few days all the secretions and the tissues in different parts of the body responded to the iodine test.

The injections had to be made with great care, as they were often followed by acute inflammation of the skin and subcutaneous cellular tissue. Four months later all of the animals were inoculated. The three control animals died of tuberculosis in from thirty to fifty days; the iodoformized animals showed a partial immunity, and manifested no symptoms of tuberculosis until the expiration of fifty days, and death did not occur until from the seventieth to the ninetieth day after inoculation.

The same experiments were repeated three times with identical results. In two instances the iodoformized animals were killed, respectively, on the twenty-fifth and thirtieth days after operation.

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Nothing further was found at the point of inoculation than a slight circumscribed peritonitis in one and a limited area of adhesion between the peritoneal surfaces in the other. Examination of specimens stained by Ehrlich's method showed numerous bacilli in the adherent parts, and a fragment of lymph deposited on the surface implanted into the peritoneal cavity of a guinea-pig caused death from tuberculosis in twenty-seven days. Iodoformized guinea-pigs proved more refractory to the tubercle bacillus than rabbits; in one instance the animal lived one hundred and two days after inoculation.

In another very interesting series of experiments, Gosselin reversed the experiments, rendering the animals first tubercular by inoculation and then resorting to treatment with iodoform. In these experiments rabbits and guinea-pigs were used.

Soon after the animals were inoculated with tubercular matter, daily subcutaneous injections of two to three drops of iodoform ether (1 to 10) were made, suspending the treatment as soon as iodoform intoxication set in and beginning anew when it disappeared, grading the absorption of iodoform so as to obtain the maximum impregnation of the organism with this drug compatible with life in the shortest possible space of time.

The experiments showed that susceptibility to iodoform differs not only in the same species of animals, but also in different members of the same family. If the animal is not closely watched it will die quickly, poisoned by the combined action of ether and iodoform.

Three rabbits and two guinea-pigs remained well ninety-five days after inoculation, and were killed, and the most careful search showed no trace of tuberculosis at the point of inoculation, and all of the organs presented a perfectly healthy appearance.

Two rabbits and one guinea-pig were in good health one hundred and sixty days after inoculation. The two rabbits were considerably emaciated and their appetite somewhat diminished.

These symptoms were due to the iodoform, for as soon as the use of this remedy was suspended the animals were restored to perfect health. The dose of iodoform was diminished every five days for a fortnight. A third rabbit died from iodoform poisoning on the thirteenth day, and a careful autopsy did not reveal a trace of tuberculosis. At the seat of injection there was a circumscribed inflammatory exudation, apparently free from bacilli. Two guinea-pigs were inoculated with fragments of tissue from this place, and these animals, with the exception of slight emaciation, remained in good health one hundred and sixty-one days later.

These studies appear to prove that the prolonged use of iodoform by subcutaneous injection, carried to the point of toxic symptoms, prevents, or at least retards, the extension of the tubercular process.

Thiéry* does not believe that iodoform possesses such direct antitubercular properties as expressed by Gosselin, but he is willing to admit that it has a potent influence in retarding the tubercular process. In opposition to the conclusions drawn by Gosselin, he reminds his readers that it is well known that tuberculosis, under favorable circumstances, is occasionally spontaneously cured or curable. In one hundred and thirty-one autopsies made at the Morgue Vibert he noticed evidences of a former tubercular process, which had become arrested spontaneously, and the patients succumbed to other diseases. In seventeen out of the twenty-five cases the former tubercular depot was indicated by a cicatrix or chalky deposit. As further proof that tuberculosis does not always manifest progressive tendencies and undergoes a cure unaided by medication may be mentioned the writings of Leroux, Cruveilheir,† and Rogée, who, in his work,‡ makes the statement that in fifty out of one hundred autopsies, which he made on old men, he found evidences of pulmonary phthisis which had been completely

* De la Tuberculose Chirurgicale, etc., Paris, 1890, p. 485.
† Anat. Path. Gén., T. x, p. 616.
‡ Arch. Path. Gén de Méd., 1829, T. v.

cured. Boudet* and Gaucher† studied carefully the process of spontaneous cure of tubercle by cicatrization. Similar and other observations in the same direction were made by Grisolle, Guencon de Mussy, Lebert, Jaccoud, Herard, Cornil, Peter, and, lastly, the work of Thavu.‡

Jeannel§ has made experimental investigation in the same direction, concerning the curability of tuberculosis, as Gosselin.

He made the following four series of experiments:—

1. Local treatment alone.

2. Local and general treatment combined.

3. General treatment alone from the beginning of the disease.

4. General treatment alone from a period remote from the beginning of the disease; that is, from the time inoculation was made.

On the whole, the results were not very encouraging. The local treatment alone or combined with general treatment did not prevent the development of tuberculosis; all of the inoculated rabbits died from well-marked tubercular affections, and the treatment did not even retard the progress of the disease or postpone the fatal termination. General treatment alone, inaugurated at the time the inoculation was made, proved also inefficacious, and Jeannel even intimates that the treatment by iodoform ether has neither the power to cure nor to retard tuberculosis in the rabbit. Finally, general treatment alone, instituted at a period remote from the beginning of the disease, was a complete failure in every respect. Remarking how these results were so widely at variance with those claimed by Gosselin, the latter replied that he positively maintained the assertion previously made concerning the curability of local tuberculosis by treatment with iodoform injections. He at the same time

* Thèse de Paris, 1843.

† Archives de Physiologie, 1878.

‡ Clinique Chir. des Mal. Chron., 1877.

§ "Recherches sur la Géneralisation de la Tuberculose Expérimentale," Congrès de la Tuberculose, Paris, p. 351. "Nouvelles recherches expérimentales sur la tuberculose et sa curabilité," Etudes sur la tuberculose, fasc. ii, p. 416.

insisted that generalization of tuberculosis varies with the place where the inoculation is made.

The discrepancy of the views entertained by these French investigators leaves the experimental field concerning the curability of tuberculosis by the local and subcutaneous use of iodoform open for future research to determine definitely the value of this remedy in the treatment of this disease.

CHAPTER XXIV.

Treatment of Tuberculosis of Joints by Parenchymatous and Intra-articular Injections (*continued*).

Clinical Results.—The clinical results have been more uniformly in support of the antitubercular action of iodoform than the conclusions drawn from experimental work. The iodoform treatment of tubercular affections of bones and joints found an enthusiastic advocate, in France, in the person of Verneuil;* through his example and influence it found ready adoption at once in different parts of that country by the most prominent surgeons.

Vercherè† expresses himself as highly pleased with the results obtained by injections of ethereal solutions of iodoform, as advised by Verneuil a year after the latter surgeon published his first paper on the subject.

Segond‡ restricts the use of the iodoform treatment to patients greatly debilitated by the disease, and in cases in which the primary disease is inaccessible to radical measures.

Barrette§ reports twenty-eight observations of his own, with very favorable results. Among these was a man, aged 33, with tubercular osteomyelitis of the fourth rib, complicated by incipient pulmonary phthisis. The cold abscess, which had developed in connection with the rib, was treated by iodoform injections, and the local lesion was cured.

Two cases of cold abscess originating from the spine were also cured. In one case, in which an abscess started from a tubercular focus, after resection of the elbow, the injections were followed by death from iodoform intoxication. The necropsy revealed an incurable chronic affection of the kidneys.

* "Injections d'ether iodoformé dans les abscès froids." Revue de Chirurgie, 1885, p. 428 et sequi.

† Revue de Chirurgie, 1886, pp. 476–502.

‡ "Abscès Tuberculeux de la Cuisse, injections d'ethor iodoformé on operation sanglante." Gazette des hôpiteaux, No. 146, 1887.

§ "Sur le traitement des manifestations externes de la tuberculose." Congrès de la Tuberculose, p. 586.

Reclus,* in giving his results of this method of treating tubercular affections, reports only two complete failures; five improved; meanwhile two died of slow tubercular lung complications. Eight recovered in spite of large collections located where operation was practically impossible, and in nine cases the final outcome could not be learned. He injects into large abscesses from 60 to 120 grammes of a 5-per-cent. solution of iodoform in ether. The injections to be repeated in from three to four weeks; and in some cases the injection has to be repeated a third and a fourth time. After the injections the abscess-wall becomes greatly disturbed by the ether-gas; if the vitality of the overlying skin is considerably impaired, necrosis may take place from the pressure. In such cases the ether-vapor is to be removed by inserting a small trocar. In a few cases this treatment was followed by suppuration and the formation of a fistula, which, however, soon healed. He is of the opinion that in all of the cases in which a cure followed, the same result could have been obtained by incision and curetting, but the latter treatment would have required more time and would have left unsightly scars. In favor of the iodoform treatment, he also maintains that it is less likely to be followed by a relapse, and cites Trélat, Guyon, Bouilly, Nélaton, Richelot, Quenu, Peyrot, and Bruns as entertaining the same opinion.

Tilanus† studied the antiseptic and antibacillary properties of iodoform, and concludes that it is a useful remedy in the treatment of tuberculosis.

Villemin‡ is of the opinion that iodoform is deserving of the confidence of the surgeons. The French surgeons have employed almost exclusively the ethereal solutions of iodoform (5 to 100), and we hear of cases in which, like in some of the experiments on animals, the injections caused a violent local inflammation and even gangrene. The injection is also

* Gazette Hebdomadaire, 1887.

† "Propriétes de l'iodoforme." Revue de Chirurgie février, 1890.

‡ Etude experimentale de l'action de quelques agents chimiques sur le development du bacille de la tuberculose, 1888.

painful, as the temperature of the body is sufficiently high to vaporize the ether in a very short time after its injection, which causes painful and sometimes dangerous tension in the joint or abscess. It appears also that iodoform intoxication occurs more frequently when the ethereal solution is used than when the iodoform is injected in the form of an emulsion in glycerin or in olive-oil. A case of death from iodoform intoxication was alluded to above, and another occurred in the practice of Barvis.*

The patient was a soldier, aged 24, the subject of a large cold abscess in the region of the left wall of the chest. This was punctured, and, after evacuation of its contents, from 50 to 60 grammes of a 5-per-cent. ethereal solution of iodoform were injected. Immediately after injection the patient went into collapse, and it is possible that some of the fluid was injected into the pleural cavity. In explanation of the sudden death it may be suspected that a small quantity of the ether-vapor was forced into the venous circulation, and that the collapse was caused by ether-vapor embolism; but Barvis attributes death in this case to acute iodoform intoxication. In view of the fact that ether-iodoform injections are always productive of pain, and not infrequently produce intense local reaction, and that the ether used may become a source of danger, and that they are more liable to give rise to intoxication than when iodoform-glycerin emulsion is used, the latter preparation should be used exclusively. In Germany the latter method of administration is used almost exclusively.

Bruns uses a 10-per-cent. mixture of iodoform in glycerin or olive-oil, always taking the precaution to sterilize the mixture. Krause recommends the following mixture:—

℞	Iodoform. subt. pulveris, ...	50.00
	Mucil. gummi arab., ...	2.30
	Glycerini, ...	83.00
	Aq. destillat., ... q. s. ad	500.00

Sig.: Ten-per-cent. iodoform mixture. To this mixture he adds 1 per cent. of pure carbolic acid.

* "Du traitement des Abscèss froids, Intoxication iodoformique mortelle." Arch. de Méd. et de Pharmacie, T. xvi, No. 8, 1890.

Whatever formula for the solution is selected, not more than half a drachm of the iodoform should be injected at the first time, and in children even less. If this dose does not produce any unpleasant symptoms it may be increased the next time the operation is repeated. If used in this manner the risk of iodoform intoxication appears to be *nil*, or at least very remote, as not a single instance was observed in one hundred and eight cases treated in the Tübingen clinic by Bruns. The best results with iodoform injections come from the Halle and Tübingen clinics. This is undoubtedly owing to the fact that in these institutions this treatment has been very extensively used, and the large experience thus gained has enabled the surgeons to make a proper selection of cases and apply the treatment in the most efficient manner.

Bruns* injects, every two weeks, a mixture composed of 10 parts of iodoform, 50 of glycerin, and 50 of distilled water. In his first report he states that of fifty-four cases of tubercular abscess forty have recovered under this treatment.

In a later publication the same author† asserts that the antitubercular action of iodoform has been demonstrated. In order, however, for this drug to exert its specific action it is necessary that the whole interior surface of a joint or tubercular abscess should be acted upon, and the action should be uninterrupted and continued for a long time. The curative effect often only becomes apparent after three or four months, but from this time the abscess gradually disappears. Of one hundred cases of tubercular abscess treated in his clinic during the last five years 80 per cent. were cured, and during four years fifty cases of joint tuberculosis were also cured. He uses now a 10- to 20-per-cent. mixture of iodoform in pure glycerin or olive-oil, prepared fresh and thoroughly sterilized before each injection.

* "Ueber die antituberculöse Wirkung des Iodoforms." Verh. der Deutschen Gesellschaft, f. Chirurgie, 1877.

† "Ueber die Behandlung tuberculöser Abscesse und Gelenkerkrankungen mit Iodoforminjectionen." Beiträge zur klinischen Chirurgie, vi, 3, p. 639, 1890.

In the case of fungous joints he makes the injection not only into the cavity of the joint, but also into the thickened capsule, making the puncture at different points, and injecting from 2 to 6 centimetres of the mixture. In tubercular hydrops and tubercular abscess the fluid or softened contents are first removed, whereupon 10 to 30 centimetres of the mixture are injected.

Neither pain nor symptoms of local irritation follow the procedure, but the temperature usually shows a rise of from one to two degrees, which, however, disappears after a few days. He does not immobilize the injected joints. He has never met with cases of iodoform intoxication from the injections. Parenchymatous injections are to be repeated every eight days, intra-articular injections every two to four weeks. Symptoms of improvement seldom appear before the expiration of six to eight weeks, although the pain diminished at an earlier date.

Shrinking of the fungous capsule is the surest indication of beginning improvement. In children suffering from tuberculosis of joints the functional result is frequently perfect if the treatment is begun before the disease has resulted in extensive destruction of the soft structures of the joint. In adults the best results often consist in a useful but partially or completely ankylosed limb.

Wendelstadt* uses a mixture of iodoform in olive-oil in the proportion of 5 to 25. He insists that the mixture should be prepared fresh every time, as in mixtures kept for some time free iodine is generated, the presence of which can be recognized by the mixture presenting a brownish-red color.

As a parenchymatous injection, he throws from 2 to 3 centimetres of this mixture into the tissues with an ordinary Pravaz syringe. The injection is repeated every eight days; the puncture should always be made at a different point in order to reach, successively, different parts of the focus.

* "Zur Behandlung der tuberculösen Knochen und Gelenkerkrankungen durch parenchymatöse Injectionen von Iodoformol." Centralblatt f. Chirurgie, No 38, 1889.

In several cases he observed a rise in the temperature to 40° C. the same day, but the febrile reaction always subsided in a short time. This method was applied in 109 cases of local tuberculosis; of this number, 28 were later treated by incisions and *évidement*. A permanent cure was obtained in 36; improved, 37; not much benefited, 12, and 24 remained under treatment.

Andrassy* gives the particulars of the 22 cases of cold abscesses treated by iodoform injection that were first reported from the Tübingen clinic by Bruns. Of this number, 20 were perfectly and permanently cured. In one case the abscess had to be opened. The largest dose of iodoform used was 10 grammes. No symptoms of intoxication were observed in any of these cases, but occasionally a considerable rise in temperature followed the procedure. In most cases the operation had to be repeated two or three times at intervals of two weeks. The healing process was generally completed in from one-half to two and one-half months.

Billroth† uses a 10-per-cent. iodoform-glycerin emulsion. The tubercular joint or abscess is evacuated and from 40 to 50 grammes of the mixture are injected. The injection is not repeated until the urine no longer reacts to the iodine test.

During two years, Krause‡ treated tubercular affections of the following joints by intra-articular injections of iodoform:—

Knee-joint,	36
Hip-joint,	13
Tarsal joint,	6
Wrist-joint,	5
Elbow-joint,	1

The treatment was not completed in all of these cases, but a cure had been effected in the following:—

* "Beiträge zur Behandlung der kalten Abscesse, insbesondere mittelst Iodoforminjectionen." Bruns' Beiträge zur klinischen Chirurgie, ii, 1887.

† "Ueber die Behandlung kalter Abscesse in tuberculoser Caries mit Iodoform Emulsion."

‡ "Ueber den heutigen Standpunkt in der Behandlung der tuberculösen Knochen und Gelenk Krankheiten." Berl. klin. Wochensehrift, No. 49, 1890.

Knee-joint,	15
Hip-joint,	4
Tarsal joint,	1
Wrist-joint,	3

Three of the cases that were cured were sent to the clinic to undergo an amputation.

Although in the cases where the wrist-joint was involved the treatment failed in restoring motion, it made the fingers more movable and useful. In the hip-joint cases, recovery usually resulted in almost total ankylosis.

This was evidently due to the fact that the severest cases were subjected to this treatment, and much better functional results can be expected if this treatment is commenced during the early stages of the disease.

Improvement was noted in nearly all cases that remained under treatment. The best results were realized from the treatment in tuberculosis of the knee- and wrist- joints. He recommends that, if the cannula of a large trocar is not large enough through which the joint can be completely emptied of its contents, an incision should be made for this purpose, and the wound sutured before the injection is made.

Of the cold abscesses which were subjected to treatment by iodoform injection, 50 per cent. were cured. He believes that intoxication symptoms are not produced by using emulsion of iodoform, because none of the iodoform is in solution, and on this account absorption is very slow. He has injected the emulsion which he uses in doses varying from 5 to 80 grammes. The injections never caused much pain, but were often followed by a rise of temperature for a short time. The first symptoms which denote that improvement is taking place are lessening of pain and diminution of swelling. Peri-articular abscesses recurred several times after they were apparently cured, and required repetition of treatment.

Trendelenburg has treated one hundred and thirty-five cases, of all grades of severity, by the injection method, making one injection of 5 grammes every eight days. The most striking

results were obtained in wrist-joint tuberculosis in adults,—a disease which usually gives a bad prognosis and frequently necessitates amputation. In 68 per cent. of all cases, the treatment had a favorable effect.

Immediate and Remote Dangers Attending Iodoform Injections.—The dangers attending the treatment of tubercular affections of bones and joints by iodoform injections may arise from iodoform intoxication, the action of the menstruum employed, secondary infection, and injury of important parts by the instrument used in making the puncture.

In a case of Boeckel's,* the patient died during the operation. It was found that the abscess communicated with the subclavian artery. In three of König's† cases the puncture of the abscess was followed by profuse hæmorrhage, due to arterial erosion. The arteries involved were the gluteal, the deep femoral, and the external plantar. These had to be ligated. A similar complication occurred in two cases under the care of Lindner:‡ one of fatal hæmorrhage from the femoral and the other from the iliac vein.

Dollinger§ does not approve of the iodoform-ether injections as advised by Verneuil, as he has found in his experience that in children they did not induce recovery in a single case. He not only regards them useless, but harmful, as the injection of even small doses produced deafness, headache, and nausea, while larger quantities were followed by loss of consciousness, impaired respiration, and acute cystitis. At the moment of injection some headache may be felt, and there may be an evening rise of temperature of 3 to 4 degrees. The rapid evaporation of the ether may cause necrosis of the abscess-wall, and if, for example, psoas abscess from rapid overdistension should rupture into the peritoneal cavity, death might result from such injections from septic peritonitis.

* London Medical Record, 1889.

† Centralblatt f. die gesammte Therapie, 1887.

‡ Deutsche Med. Wochenschrift, 1887.

§ "Beiträge zur Iodoform-ether behandlung der tuberculösen Knochen entzündung." Centralblatt f. Chirurgie, May 18, 1889.

Heusner* reports a case of iodoform intoxication caused by an intra-articular injection of 0.1 gramme of iodoform in glycerin. Bramann observed quite grave symptoms of intoxication after an injection containing 2.0 grammes of iodoform. The patient was a boy. Later, the injection of the same amount produced no untoward symptoms.

Trendelenburg first used iodoform-ether, but in a short time the injection produced gangrene of the overlying abscess-wall in three cases, and after that he has used the emulsion exclusively and has not observed such a result since. Gangrene of the overlying tissues and iodoform intoxication have only been observed after iodoform-ether injections; the first is caused by the overdistension resulting from vaporization of the ether, and the latter is due to rapid absorption of the iodoform kept in solution by the ether. Another possible remote source of danger attending the injection of the ethereal solution is the entrance of ether-vapor into one of the veins, causing death from ether-embolism.

The dangers just enumerated do not belong to injections of iodoform held in suspension in glycerin or olive-oil. Accidental infection, which has occasionally occurred during or after the injection, is, of course, caused by a faulty antisepsis, and has happened from the use of iodoform by parenchymatous and intra-articular injections, irrespective of the menstruum used. If such an accident take place, it will become necessary to make a puncture with a large trocar and evacuate the pus through the cannula, and resort at once to irrigation with a 3-per-cent. solution of boric acid, or treatment by incision and drainage may be required. Dangerous hæmorrhage is occasionally encountered in treating tubercular abscesses by incision and scraping when a vessel of considerable size has become eroded, and the possible occurrence of this accident does not militate against the treatment by iodoform injections.

Action of Iodoform on Tubercular Tissue.—If iodoform, in

* Berl. klin. Wochenschrift, October 5, 1891.

the form of an emulsion, is injected into an empty tubercular joint or abscess, and an effort made to diffuse it over the whole interior surface by passive motion, pressure, and rubbing, the fine particles of iodoform will soon be equally distributed over the entire surface clinging to the granulations, fibrinous masses, or the cheesy material lining the cavity. The iodoform produces no violent irritation; its action on the tissues is mildly stimulating. The re-accumulation of fluid in the joint or tubercular pus in the abscess is slow, and if the procedure is repeated after eight days to two weeks the fluid withdrawn will contain particles of iodoform, showing that the absorption of this substance, when not applied in solution, is very slow. At the same time the fluid will have changed its character somewhat, containing elements the presence of which indicates that remnants of dead tissue, products of coagulation necrosis, are being thrown off, and that a reparative process has been initiated. The first effect of the iodoform on the tissues lining the joint or cavity is to bring about rapid disintegration of the tubercular product, which then is displaced by a layer of active and very vascular granulations.

Bruns and Nauwerk* incised tubercular abscesses treated by iodoform injections at different intervals after the injection and extirpated pieces of the abscess-wall for microscopical examination. A few weeks after injection they found that the tubercle bacilli had disappeared, the miliary tubercles softened by infiltration with round-cells and œdematous inhibition of a serous fluid; further on the tubercles disappeared by fatty degeneration of the cells and liquefaction of the cellular detritus. Hand in hand with the degeneration and liquefaction of the tubercular product could be witnessed, in the adjacent tissues, a process of repair, in the shape of a wall of granulation tissue, which formed a line of demarcation between the healthy and diseased tissue, which consumed in part the dead sterile tuber-

* "Ueber die antituberculöse Wirkung des Iodoforms, Klinische und Histologische Untersuchungen." Beiträge zur Klinischen Chirurgie, iii. Tübingen, 1887.

cular tissue and detached the balance. As soon as the dead tissue was disposed of by absorption the granulations began to cicatrize, and were gradually converted into connective tissue, and with this change the process of the healing was completed. Krause made similar examinations and corroborates the observations made by Bruns and Nauwerk. That the curative effect of iodoform, in the treatment of tubercular joints and abscesses, is not owing to the mere puncture and evacuation, but is brought about by the specific action of iodoform on the tubercular products, there can be no doubt, as tapping for these conditions was employed long before iodoform was used in surgery, but this procedure seldom yielded more than temporary relief. Stockma treated five tubercular abscesses by tapping alone, but always with negative results. If he injected the contents of tubercular abscesses, treated by different methods, into the anterior chamber of the eye in rabbits the result was always positive except in the case of abscesses treated by iodoform injections, in which a sufficient time had elapsed for the iodoform to exert its specific antibacillary effect. Iodoform exercises a double therapeutic action on tubercular tissue when used by parenchymatous or intra-articular injections; it destroys the bacillus of tuberculosis and aids the removal of the dead sterile tissue, and favors the subsequent reparative process by its stimulating action on the surrounding healthy tissue,—properties not possessed, to the same degree, by any other as yet known substance.

Indications.—The curative power of iodoform injections has so far been most manifest in the treatment of heretofore most hopeless cases of surgical tuberculosis,—tubercular abscess in connection with an inaccessible osseous focus. One of the most brilliant achievements of modern surgery is the successful treatment of tubercular abscesses developing in the course of tubercular spondylitis by iodoform injections. Statistics show that more than 50 per cent. of such cases are amenable to this method of treatment. In the successful cases not only the abscess but the primary bone-lesion is also cured.

One of the most striking illustrations of the efficiency of iodoform treatment in these grave cases recently came under my observation. The patient was a delicate girl aged 8, who had suffered from a tubercular spondylitis at the junction of the last dorsal with the first lumbar vertebra for six months. Slight angular posterior curvature. Within two months an enormous abscess developed in the right lumbar and iliac regions. Below the abscess extended as far as Poupart's ligament, above to the last rib. The abscess was very prominent in the lumbar and inguinal regions. The child had a temperature of 104° F. every evening. The abscess was punctured, under strict antiseptic precautions, in the lumbar region, and nearly two quarts of tubercular pus evacuated. The abscess-cavity was irrigated with a 3-per-cent. boric-acid solution until the fluid returned perfectly clear, and 2 ounces of a 10-per-cent. mixture of iodoform in glycerin injected. The puncture was sealed with a pledget of antiseptic cotton and iodoform collodium.

The first injection had no effect in reducing the temperature; at the end of a week it was repeated, and about half as much tubercular pus removed. The temperature, in a few days after the second injection, was normal. The third and last injection was made four weeks after the first. At this time only about six ounces of a viscid fluid were removed. The child improved in general health, and after this time no re-accumulation of fluid occurred. At the present time, six months after treatment was commenced, the child is wearing a plaster-of-Paris corset, and appears to be in perfect health.

No one who is familar with the efficacy of iodoform injections in the treatment of tubercular abscesses would or should neglect to resort to it when called upon to treat tubercular abscess in communication with an inaccessible primary tubercular focus. This applies with special force to abscesses developing in connection with tuberculosis of the vertebræ and some of the pelvic bones.

This treatment is again applicable, and has yielded excel-

lent results, in tuberculosis of the knee and other readily accessible joints, with or without the formation of para-articular abscesses.

The treatment is most useful if the joint is distended with fluid, as under such circumstances, after the removal of the fluid, the iodoform can be brought in contact with the entire surface of the cavity. This is often impossible if portions of the joint have been shut out by intra-articular adhesions. Irrigation of the joint should never be omitted if it contain pus, flakes of lymph, or detached, broken-down fragments of tubercular tissue, and it is in such cases that the cannula of even a large trocar is often not of sufficient size to evacuate the joint or abscess properly, and that the puncture has to be followed by an incision large enough to meet the requirements.

If the joint contain no fluid it is difficult and usually impossible to reach all of the infected tissues by an intra-articular injection, and it is in such cases that it must be combined with parenchymatous injections, and the site of puncture changed at each operation. As no fluid is to be removed, and no irrigation to be made under such circumstances, the necessary amount of iodoform emulsion is thrown into the joint and into the thickened fungous capsule with an ordinary Pravaz syringe, supplied with a large needle. The puncture is made at different points every time the procedure is repeated. It cannot be expected that a cure can be effected by this method of treatment if the primary focus contain large masses of cheesy material, or a sequestrum of considerable size. But even in such cases, if the injections are made with the requisite degree of care, the treatment is harmless, and results in great benefit in preparing the parts for subsequent surgical treatment by operation.

Points to be Remembered in Making Intra-articular and Parenchymatous Injections.—The strictest antiseptic precautions must be practiced in making the injections, as neglect in this direction would not only interfere with an ideal result of the treatment, but would expose the part and the patient to the

risks and dangers incident to a suppurative inflammation, with all its immediate and remote consequences. The surface where the puncture is to be made should be shaved and thoroughly scrubbed with hot water and potash soap, and carefully disinfected by washing with an antiseptic solution, and lastly with pure alcohol. The trocar should be sterilized by boiling, or passing it slowly through the flame of an alcohol-lamp. The emulsion must be prepared fresh and sterilized. If a syringe is used for making the injection, it should be one with an asbestos disc for the piston and kept in an aseptic condition. If a rubber bulb and rubber tubing is employed, these must be sterilized. The point where the puncture should be made in operating on the different large joints has already been described. The cardinal rule in all operations should be to select the shortest route from the surface into the different joints, and at a point where no important structures will come into the line of the proposed puncture. In injecting a tubercular abscess the puncture should not be made where the abscess-wall is thinnest, but some distance from the most prominent point of the swelling, so that the puncture will be made through healthy skin, and not through tissues reduced in vitality from the long-continued pressure from beneath. Before the puncture is made the skin is drawn to one side so that after the removal of the cannula the puncture in the deep tissues may be subcutaneous.

The ethereal solution of iodoform should never be employed, as its use is attended by greater immediate and remote risks than if the iodoform is used in suspension in a non-volatile menstruum.

The best method of using the iodoform is a 10-per-cent. mixture in glycerin or olive-oil. The quantity of the mixture to be injected must vary somewhat according to the age of the patient and the size of the tubercular focus. From 3 drachms to an ounce is the average dose. In injecting a tubercular joint, which contains fluid or a tubercular abscess, irrigation with a 3-per-cent. solution of boric acid should be employed until the

fluid returns perfectly clear before the iodoform injection is made. If the joint or abscess-cavity contain broken-down tubercular products, which cannot be removed through a large cannula, the joint or abscess should be freely incised, the interior scraped and rubbed out with iodoform gauze, wound sutured, and then the injection made,—a plan of treatment practiced with great success by Billroth.

In making parenchymatous injections the needle should be inserted in different directions without removing it completely, and the injection made at as many points as possible in order to saturate as large a territory as possible of the infected tissues. If the procedure is to be repeated the puncture is made some distance from the first so as to medicate a new area of tubercular tissue.

After the cannula is withdrawn the puncture in the skin should be carefully sealed with a pledget of aseptic cotton and iodoform collodium. Mechanical diffusion of the injected material should be secured after the injection by kneading, compressing, and rubbing the parts, and by making passive motion. The injection is not to be repeated oftener than every eight days to two weeks, and the treatment continued until the tubercular material has been removed and healing by cicatrization is in progress.

In the treatment of tubercular joints by iodoform injections, immobilization is only necessary if active motion of the joint is productive of great pain. In tubercular spondylitis, with abscess, the iodoform treatment should be combined with the necessary orthopædic treatment. In tuberculosis of bones and joints, with a large caseous mass or a sequestration of considerable size at the primary focus, the iodoform treatment cannot take the place of mechanical removal of the infected and dead tissue, but is often of great value as a preliminary measure to prepare the way for a radical operation.

Cases of Tuberculosis of Bones and Joints Recently Treated by Iodoform Injections in the Surgical Clinic of Rush Medical

College.—The most brilliant result of treatment by iodoform injections that came under my own personal observation was the case of tubercular spondylitis reported on page 266. The local and general improvement was manifest after the second injection, and complete cure, not only of the enormous abscess, but also of the primary bone-lesion, was realized in less than three months.

The cases reported below were treated in the clinic of Rush Medical College since April, 1891. In some of the cases the ultimate result of the treatment could not be ascertained, as the patients failed to report. A 10-per-cent. emulsion of iodoform in glycerin was the preparation used exclusively. The intra-articular injections were made with a two-ounce glass syringe, which was connected with the cannula, after withdrawal of fluid, or, in case the joint was irrigated with a solution of boric acid after completion of this procedure, by a piece of aseptic rubber tubing which was tied firmly over the distal end of the cannula and the nozzle of the syringe. Special care was exercised to prevent the entrance of air into the joint. As a rule, the patients were permitted to use the limb moderately during the entire treatment. An exception to this rule was made in the cases of tuberculosis of the hip-joint, and in affections of the knee-joint when the joint was much contracted.

In no case was the injection followed by suppuration, intoxication, or any other immediate or remote untoward symptoms. As a rule, the pain following the injection was slight and of short duration. The injection was always followed by some swelling, which reached its maximum about the second day. Improvement of the joint-lesion was always announced by a change in the character of the effusion in the cases in which this condition of the joint existed. If the joint or abscess contained tubercular pus, the first change noticed was gradual disappearance of the solid portion of the fluid, such as shreds of lymph and fragments of tubercular tissue; at the same time the fluid became more viscid, bearing a strong resemblance

to thin mucus. As soon as this stage was reached the effusion disappeared speedily and permanently, with contemporaneous improvement of all the remaining symptoms.

Case I. Laboring man, aged 27; has inherited a rheumatic tendency; presented himself for the first time in the clinic, April 23, 1891; general health unimpaired; no signs or symptoms of pulmonary tuberculosis. Nine months ago he experienced pain on the inner side of the right knee-joint. This pain was not constant, but was always aggravated by active exercise. Five months later the joint became swollen. When first examined, the joint was uniformly swollen; movements of limb unimpaired; upper recess of synovial sac quite prominent; fluctuation distinct; no tender points over condyles of femur or head of tibia. Primary synovial tuberculosis with hydrops was the diagnosis made at the time.

The joint was punctured with a medium-sized trocar and about four ounces of a turbid synovial fluid, in which small flakes of lymph were suspended, were removed. The tapping was followed by irrigation of the joint with a 3-per-cent. solution of boric acid until the fluid injected returned perfectly clear. One ounce of iodoform emulsion was injected. The patient was advised to use the limb moderately. During five weeks the same procedure was repeated three times, and at each successive tapping the fluid removed was less in quantity and more viscid. When the patient was seen again, after the fourth injection, the joint presented a normal appearance; no effusion, and thickening of capsule nearly disappeared; motion of joint nearly normal. As the patient has not reported since that time, it is fair to assume that he has completely recovered.

Case II. Boy, aged 8, with good family history, entered the Presbyterian Hospital, October 25, 1890, suffering with hip disease. The disease commenced soon after an injury, which he received in April, 1889. Rest in bed and extension by weight and pulley was the treatment employed. Under this treatment the pain subsided, but the swelling and tenderness

remained stationary. During the month of May three injections, from two drachms to half an ounce of the emulsion each time, were made into the joint. As it was almost certain that the head and neck of the femur were the primary seat of the inflammation in this case, I made it a point to penetrate the neck of the femur deeply with the small trocar in order to attack existing osseous foci by the same treatment. The emulsion was first thrown into the substance of the bone, and, later, after withdrawing the cannula as far as the surface of the bone, into the joint.

Several days after the last injection the pain became suddenly aggravated, and the limb shortened in spite of the fact that extension was kept up uninterruptedly; at the same time the limb was rotated inward. It was now decided to resect the joint. The operation was performed June 7th. The great trochanter, with the muscles attached to it, was cut away from the shaft at the base of the neck of the femur with a chisel, and, after the resection of the joint, was replaced and fastened to the shaft with two catgut sutures. Inspection of the joint now explained the symptoms which had developed recently so suddenly.

The head of the femur, partially destroyed, had slipped out of the acetabulum and was resting upon its upper brim. A number of foci were found in the neck of the femur, in close proximity to the head; the joint was filled with granulations. No signs of caseation. The granulations were firm and of a bright-red color, and I have no doubt had this accident not occurred the parenchymatous and intra-articular injections would have resulted finally in a cure. The neck of the femur was divided at its junction with the shaft with a broad chisel, and removed with the head. The capsule was extirpated, and the granulations lining the acetabulum scooped out with a sharp spoon. Extension in abducted position was continued for several weeks. Primary healing of the wound and only very slight shortening, with leg in excellent position.

Case III. Farmer, aged 53, with a family history of tuberculosis, came to the clinic to be treated for tuberculosis of the wrist-joint of three years' standing. General health fair; muscles of arm atrophied; hand slightly flexed; arm in position half way between pronation and supination. Swelling extended over the entire wrist-joint, and presented all the characteristic clinical features of tuberculosis of this joint. During the course of five weeks he received three iodoform injections, the quantity of emulsion used each time being sufficient to fully distend the joint. After the second injection the swelling and pain began to subside, and four weeks later the joint was practically cured. The injections were always made below the styloid process of the ulna or radius, from which point the trocar was made to traverse the entire joint from side to side; the injection was made slowly and at different points as the cannula was withdrawn.

Case IV. Girl, aged 4, with good family history, was brought to the clinic June 25th, suffering from typical tuberculosis of the right knee-joint. The disease commenced five weeks before, with pain and lameness. No evidence of tuberculosis in any other organ; general health fair; knee-joint slightly flexed, but only moderately swollen; no effusion in joint; capsule thickened, and upper recess of synovial sac evidently the seat of fungous granulations. Tenderness over the internal condyle of the femur suggested an osseous origin of the intra-articular inflammation. The knee-joint was punctured, but no fluid escaped. In order to ascertain whether the whole knee-joint could be medicated by intra-articular injection, boric-acid solution was forced into it from a fountain syringe until the whole joint was fully distended; it held about two ounces. Half an ounce of iodoform emulsion was then injected. The joint became more swollen, painful, and tender after the first injection. The same quantity was injected July 11th, August 4th, and September 1st.

At the present time the position of the limb is normal,

motion of joint fair, thickening of capsule greatly diminished, and less tenderness over condyle.

Case V. Girl, aged 7, was admitted into the Presbyterian Hospital, March 24, 1891, with well-marked advanced tubercular disease of hip-joint of two years' duration. The little patient was anæmic and emaciated. Treatment by extension and parenchymatous and intra-articular injections of iodoform. March 24th, April 28th, and May 28th, ½ ounce of iodoform emulsion was injected into the neck of the femur and hip-joint. At first the patient appeared to improve, but later her general condition became gradually worse, and an abscess formed. Resection of the hip-joint was made July 16th. September 9th the wound was nearly healed and the general condition much improved. The resected specimen contained a number of caseous foci, which, at least in part, would explain the failure of the iodoform treatment.

Case VI. Girl, aged 7, child of healthy parents, has been suffering for two months from chronic inflammation of the knee-joint. Swelling has only recently appeared; limb is flexed at an angle of 140 degrees; pain aggravated on motion of the joint; no fluctuation; tenderness over condyles of femur. Diagnosis: Dry fungous synovitis with osseous foci in condyles of femur. Half an ounce of iodoform emulsion was injected into the joint and the thickened capsule at six different times from March 18th to July 28th. On August 13th the joint was carefully examined, and the appearances were such as to warrant the assumption that the joint-lesion was cured. Pain and tenderness on moving the joint, as well as in the condyles of the femur, had disappeard. The limb was now easily straightened, while the patient was under the influence of an anæsthetic, and immobilized in a plaster-of-Paris dressing. September 11th, splint removed; position of limb satisfactory; further treatment, consisting of massage, passive motion, directed. Patient can walk without the aid of mechanical support. Pain, tenderness, and swelling have disappeared completely.

Case VII. Laborer, aged 19; very good family history; two years ago had an attack of peritonitis, which was followed by pain and swelling of one of the wrist-joints. An abscess formed and was opened four months after commencement of joint affection. An operation was made a year ago. When patient was presented for the first time in the clinic the wrist-joint was very much swollen, and skin over it for some distance œdematous; hand flexed and forearm pronated. Fistulous openings led to carious bone; lower end of radius and ulna enveloped; suppuration slight; general health materially impaired. Évidement of joint; wound packed with iodoform gauze, and forearm, as far as base of fingers, supported by a well-padded anterior splint. The sinuses were injected with iodoform emulsion twice a week for two months. At this time the wound was healed completely, and the patient has secured good use of hand, being able to perform manual labor.

Case VIII. Laborer, aged 20; family history good. For a number of weeks patient has experienced pain in left knee-joint, which was followed by swelling four weeks ago, since which time he has not been able to follow his occupation. At the time treatment was commenced, August 11th, the knee-joint was distended with fluid, patella raised at least half an inch from anterior surface of condyles, upper recess of joint very prominent, and conspicuous bulging on each side of patella. Diagnosis: Primary synovial tuberculosis, with hydrops of joint. General health not much impaired. Joint was tapped, and ten ounces of turbid synovial fluid, mixed with shreds of lymph, removed. The joint was washed out repeatedly with a 2-per-cent. solution of boric acid until the fluid returned perfectly clear, when, by compression, the joint was completely emptied, and 1 ounce of iodoform emulsion was injected. Next day the joint was swollen as much as before the tapping. The patient returned August 25th, and stated that the treatment had proved beneficial to him. The joint was again tapped, but only half the quantity of fluid removed as the first time.

The fluid removed contained no shreds, and was clearer and more viscid than at the first tapping. The second injection produced less swelling and pain than the first. Two weeks later the swelling had completely disappeared, thickening of capsule less, and the patient has since recovered almost perfect use of limb.

Case IX. Brakeman, aged 22; admitted into Presbyterian Hospital April 15, 1891; tuberculosis not hereditary in his family. About five years ago patient experienced a sudden pain in left knee, which was followed very soon by swelling and local heat. Since that time the knee has been injured on three different occasions, and each accident was always followed by aggravation of symptoms. About eighteen months ago the pain diminished, but the patient was unable to walk without the aid of crutches. The patient was anæmic and considerably emaciated; knee-joint swollen and flexed; no effusion in joint, but capsule thickened throughout; circumscribed point of tenderness over inner tuberosity of tibia. Careful search reveals absence of tuberculosis in other organs. Diagnosis: Tubercular osteo-arthritis with a probable focus in the inner tuberosity of tibia. Two iodoform injections were made two weeks apart, but, as no improvement followed, typical resection of knee-joint, with preservation of the patella, was made May 3, 1891. The whole synovial membrane was found converted into a granulation mass, and capsule of joint much thickened. The base of two triangular sequestra in the head of the tibia projected into the joint. The articular surface of the two fragments of necrosed bone was much worn, and presented a polished surface. Primary union of wound and bony consolidation of resected ends in six weeks. The inefficacy of iodoform treatment was explained by the pathological conditions revealed at the operation. Secondary tubercular synovitis following extensive necrosis from occlusion of an artery by a tubercular thrombus or embolus is not amenable to this kind of treatment. If, in such cases, this treatment is not followed by improvement

after the second or third injection, resection is indicated and the operation should not be postponed.

It is my opinion that even in such cases the preliminary treatment by iodoform injections is of great value, as it brings the intra-articular structures in better condition for successful operative treatment. I regard intra-articular and parenchymatous injections of iodoform as the best preparatory treatment for the resection of tubercular joints in which this treatment does not meet the pathological indications.

Case X. Boy, aged 17, with a tubercular family history, applied for treatment in the college clinic, June 18, 1891. When 2 years old, symptoms of tubercular spondylitis in the dorsal region first developed. In spite of the usual treatment made use of for this affection, an extensive posterior curvature formed. The patient, although 17 years of age, is not taller than a boy of 7 or 8 years. About six months ago a swelling was detected in the left iliac region which rapidly increased in size. The patient was very anæmic and greatly emaciated. The curve involves at least eight or nine of the upper dorsal vertebræ. A fluctuating swelling, reaching from Poupart's ligament to the costal arch and extending to near the median line, was found on the left side. Diagnosis: Tubercular spondylitis of upper dorsal vertebræ, which has resulted in the formation of an immense lumbar abscess, which, in all probability, still communicates with the primary osseous lesion. The abscess was tapped in the lumbar region immediately below the last rib, and six pints of characteristic tubercular pus were evacuated. The abscess was washed out repeatedly with a solution of boric acid until the fluid returned perfectly clear, after which an ounce of iodoform emulsion was injected.

Between June 18th and August 5th, tapping, irrigation, and injection was repeated four times. At each tapping the quantity of fluid removed was less, so that the last time not more than four ounces of a viscid, opaque fluid were removed. Since then there has been no re-accumulation of fluid, and the

general condition of the patient has very much improved. In its results the treatment, in this case, has proved equally satisfactory as in the case of tubercular spondylitis described above. These two cases have satisfied me that the iodoform treatment will prove most beneficial in the treatment of chronic abscesses which develop in the course of tubercular spondylitis. The value of this method of treatment in such cases cannot be overestimated, inasmuch as little can be expected from operative treatment in tuberculosis of the vertebræ.

It is only by keeping such cases under observation for months and years that reliable statistics as to the ultimate results of this as well as any other method of treatment for tubercular affection of bones and joints can be obtained. The immediate effect of the treatment has proven highly satisfactory in my hands, and, in conclusion, I can only urge its more general adoption by American surgeons.

CONCLUSIONS.

1. Parenchymatous and intra-articular injections of safe antibacillary substances are indicated in all subcutaneous tubercular lesions of bones and joints accessible to this treatment.

2. Of all substances so far employed in this method of treatment, iodoform has yielded the best results.

3. The curative effect of iodoform in the treatment of local tuberculosis is due to its antibacillary effect and its stimulating action on the healthy tissue adjacent to the tubercular product.

4. A 10-per-cent. emulsion in glycerin or pure olive-oil is the best form in which this remedy should be administered subcutaneously.

5. The ethereal solution should never be employed, as it is liable to cause necrosis of the tissues overlying the abscess and iodoform intoxication.

6. Tubercular abscesses and joints containing synovial fluid or tubercular pus should always be washed out thoroughly with a 3- to 5-per-cent. solution of boric acid before the injection is made.

7. Injections should be made at intervals of one or two weeks, and their use persisted in until the indications point to the cessation of tubercular inflammation and the substitution for it of a satisfactory process of repair, or until the result of this treatment has shown its inefficacy and indications present themselves of the necessity of resorting to operative interference.

8. If the treatment promise to be successful, symptoms pointing to improvement manifest themselves not later than after the second or third injection.

9. In tubercular empyema of joints and tubercular abscesses gradual diminution of the contents of the joint or abscess at each successive tapping, lessening of the solid contents of the fluid and increase of its viscidity are the conditions which indicate, unerringly, that the injections are proving useful and that, in all probability, a cure will result from their further use.

10. Moderate use of limb is compatible with this method of treatment, provided the disease has not resulted in deformities which would be aggravated by further use of the limb; in such cases correction of the deformity should be postponed until the primary joint affection has been cured by the injection.

11. Parenchymatous and intra-articular medication with antibacillary remedies has yielded the best results in tubercular spondylitis, attended by abscess formation and tuberculosis of the knee- and wrist- joints.

12. This treatment may prove successful in primary osseous tuberculosis followed by involvement of the joint, provided the osseous foci are small.

13. Extensive sequestration of articular ends with secondary tubercular synovitis always necessitates resection, but preliminary treatment by iodoform injections into the affected joints constitutes a valuable preparatory treatment to the operation and adds to the certainty of a favorable result.

14. In open tubercular affections of joints, incision, scraping, disinfection, iodoformization, iodoform-gauze tampon, suturing, and subsequent injections of iodoform emulsion, as advised

by Billroth, yield excellent results, and should be employed in all cases in which a more formidable operation can be avoided.

15. Balsam of Peru ranks next to iodoform in the treatment of tubercular affections of bones and joints, and if the latter remedy, for any reason, cannot be employed, or has failed in effecting the desired result, it should be given a fair trial if operative treatment is not urgently indicated.

CHAPTER XXV.

Operative Treatment.

Arthrotomy, or incision of a joint,—one of the most efficient surgical procedures in the treatment of suppurative arthritis,—has only a very limited sphere of usefulness as a therapeutic measure in the treatment of tubercular joints.

Bouilly ("Abscès tuberculeaux; intervention chirurgicale." *Gazette des Hôpitaux*, No. 9, 1887) prefers the iodoform-injection treatment in patients who are in good financial circumstances, where time is no object. In poor patients, to expedite the cure, he makes a free incision, scrapes out the granulations lining the abscess-wall, and washes the cavity with a solution of chloride of zinc and packs with iodoform gauze. For the last few years Billroth has pursued, in proper cases, a somewhat similar course. He renders the joint as accessible as possible by incisions, scrapes out the granulations, and, after irrigation, packs with iodoform gauze. This method of treatment is applicable in cases in which, either on account of unfavorable local or general conditions, arthrectomy, resection, or amputation are contra-indicated, and after subcutaneous iodoformization has been given a fair trial. The iodoform-gauze tampon should be relied upon, in securing drainage, in preference to tubular drains. This method of treatment may also occasionally be indicated and prove successful in the treatment of open or subcutaneous abscesses in communication with a tubercular joint. In cases of this kind it is of the greatest importance, after the infected tissues have been fully exposed by a free incision to direct treatment, to take special pains to procure for the seat of disease an aseptic condition by thorough antiseptic measures before the antitubercular treatment is instituted.

Arthrectomy (Volkmann), erasion of joints (Wright and Collier), synovectomy (Ollier), are synonymous terms used to

designate a modern operation on tubercular joints, consisting in the removal of the infected soft structure of the joint and the scraping out of bone-cavities, if such are present, and communicate with the joint, with preservation of the healthy portions of the articular extremities. This operation was first devised and practiced by the surgeons connected with the Children's Hospital, Pendlebury, under the name *erasion of joints*, in January, 1887. (Wright and Collier, "On Erasion or Arthrectomy of the Knee-Joint." *Annals of Surgery*, vol. x, p. 401.) The operation was intended as a substitute for typical resection in cases where the articular surfaces were intact, or only slightly involved, so that the diseased part can be removed without sawing through the articular extremity of the bone. In operating on the knee-joint, Mr. Wright first made the operation through a semilunar incision below the patella, which was later substituted by a transpatellar incision through the soft tissues and the centre of the patella. The patella was always sutured after removal of the intra-articular disease. Volkmann published his paper on "Arthrectomia Synovialis" in 1885 (*Centralblatt f. Chirurgie*). Through the influence of the distinguished author of this publication the operation has been quite generally adopted in appropriate cases, and has yielded, in the hands of a number of prominent surgeons, most satisfactory results. In his first paper on this subject, Volkmann entered his protest against the too frequent resort to excision of the knee-joint, especially in children. In young subjects this operation has proved often very unsatisfactory, on account of impairment of bone growth and subsequent contraction, and he is inclined to avoid typical resection, wherever practicable, and limit the operation to a thorough removal of the entire capsule and such superficial lesions of the bone that can be reached from the articular surfaces. He again called attention to the fact that in children, in the osseous form of tuberculosis of the knee-joint, the primary foci are usually very minute and near the articular cartilage, while in adults the disease attacks more

frequently the synovial membrane primarily. He is of the opinion that the more conservative operation of arthrectomy is urgently indicated, and offers the best prospects of a favorable issue and a good functional result in cases of so-called *fungous articuli* of the old authors, in which the capsule of the joint, the ligaments, and the parasynovial tissues form a gelatinous mass from one-half to three-fourths of an inch in thickness. The preparatory treatment consists in the correction of contractures, if such exist, by weight and pulley, or manual extension and permanent fixation, under the influence of an anæsthetic. If the disease is complicated by tubercular abscesses, these should be incised, scraped out, drained, and sutured. Fistulous tracts are to be scraped out and disinfected. I will describe here Volkmann's method of performing arthrectomy of the knee-joint. After careful preparation of the patient, the operation is commenced by opening the joint by a transpatellar incision, through which the joint can be examined by digital exploration. If this examination make it appear that it is necessary to extirpate the entire capsule, the incision is extended and the patella divided transversely with the saw. If the bursa underneath the quadriceps is extensively diseased, the incision is modified so as to make an anterior flap, the apex of which corresponds with the uppermost recess of the bursa and the base a little below the knee-joint. Esmarch's constrictor is only used in exceptional cases, as the loss of blood from parenchymatous oozing, after the removal of the constrictor, is more than would be incurred in operating without elastic constriction.

The bursa is first removed entire, and often constitutes a mass of considerable size. The lower extremity of the femur is thus exposed to the extent of three to four inches from the articular surface. The capsule and synovial membrane attached to the tibia, as well as the semilunar cartilages, are removed with the same care. The rule to be observed in these cases is to remove all diseased tissue until healthy bone and muscular tissue are reached. After removal of the soft joint-structures the

articular surfaces must be carefully inspected. In many cases they can be left intact. Osseous foci that have reached the surface should be removed with spoon or chisel, and it may even become necessary to combine the arthrectomy with partial excision. After disinfection of the fragments, the patella is sutured with catgut and the external incision closed, with the exception of the two lower angles, which are used to insert drains. The drains are placed down to, but not between, the articular surfaces. The limb is dressed in a straight or slightly flexed position. All Volkmann claims for this operation is safety and a stiff but serviceable limb. He places great stress on continuing the mechanical support for a long time, in order to prevent bending of the joint and partial dislocation of the articular surfaces. He admits that in this operation deep-seated osseous foci are occasionally overlooked, but claims that they are not always detected in complete excisions. In such cases the operation removes one of the remote dangers,—perforation of the foci into an intact joint,—and the osseous lesions can be removed later by a secondary operation. This operation has had its supporters and its opponents. It has yielded, on the whole, quite satisfactory results, in properly selected cases. It is, of course, applicable only in the treatment of tuberculosis of such joints as are anatomically so located that they can be made accessible without injuring important parts.

Sendler ("Beiträge zur Gelenk Chirurgie." *Deutsche Zeitschrift f. Chirurgie*, B. xxvii, p. 307) reports thirteen cases in which diseased joints were incised fifteen times; in four the joint was only incised (arthrotomy); in the remaining cases complete or partial arthrectomy was done for tubercular lesions. With the exception of one case, recovery was effected by the operation without reaction. In five cases a fair degree of mobility of the joint was obtained, although in two of them the synovial tuberculosis was caused by osseous foci of considerable size.

In two cases both knee-joints were affected, and recovery

with a fair degree of motion was obtained. He urges that a movable joint should be aimed at in all cases calling for simple puncture, arthrotomy, and partial arthrectomy for localized tubercular processes. The same intention should be carried out for mild diffuse tuberculosis without implication of the articular extremities, and in the milder forms of synovial tuberculosis complicated by small osseous foci, and likewise in cases of

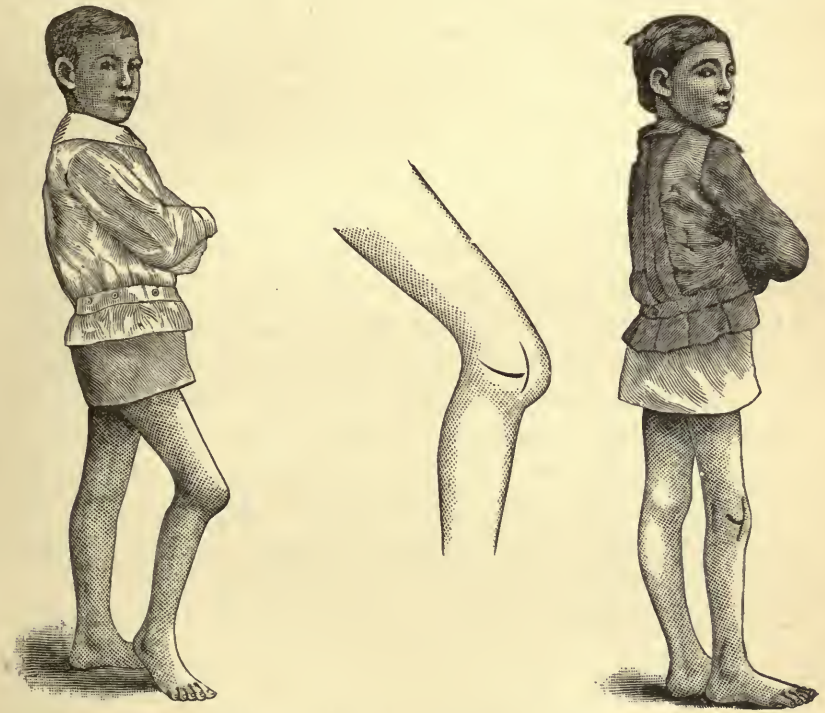

FIG. 36.—PARTIAL ARTHRECTOMY OF KNEE-JOINT. (*Medical News.*)

tuberculosis of both knee-joints; at least, in one of the joints. Ankylosis in a straight position should be aimed at in all grave forms of diffuse synovial tuberculosis, and in all severe osseous forms. If the conditions of the joint are such as to make it expedient to obtain a movable joint, the incision should be made in such a manner that the motor apparatus of the joint will not be disturbed; while this matter does not enter into

consideration if ankylosis is intended, in which case the incision is made in such a manner as to expose the joint most freely. Angerer ("Ueber Gelenktuberculose." *Münchener Wochenschrift*, No. 26, 1888) made, in two years, twenty-four arthrectomies, in children less than 14 years of age, for tuberculosis. In seventeen of these cases only the synovial membrane was extirpated, while in the remaining number a thin slice of the articular cartilages was shaved off with the knife at the same time, because the granulations had penetrated to some depth into this structure. The duration of the disease varied from three months to six years. The youngest patient was 3½ and the oldest 13½ years of age. In all cases recovery followed in from six to eight weeks, and only in two cases did local recurrence make a second operation necessary. In three of the patients a movable joint was obtained; in the rest ankylosis resulted, or at least motion was so slight as to be of no service to the patient in the use of the limb. Shortening was slight, but in a number of cases the joint became somewhat contracted.

Albert (*Internationale Klinische Rundschau*, April 14, 1889) regards arthrectomy as a useful operation, and holds that the day of typical resection is past; though he believes that conservatism, which often yields a better ultimate result than operative treatment, is not sufficiently appreciated and practiced at the present time, especially in the treatment of children.

Boeckel (*Revue de Chirurgie*, February 26, 1888), who has performed twelve arthrectomies of the knee, all successful, though two patients died later of pulmonary phthisis, favors the operation upon adults, as the mortality is less, though a longer time is occupied in the healing process. In children he prefers excision. Lucas-Championnière, with the majority of French surgeons, regards resection as the better operation, being more thorough, no more dangerous, and more quickly recovered from. Tiling ("Vorschläge zur Technik der Arthrektomie resp. Resektion," etc. *St. Petersburger Med. Wochenschrift*, Nos. 33 and 34, 1887), with a view to preserve more of the capsule and

muscular attachments of the joints in arthrectomy and resection, has proposed for the different joints temporary resection of the portions of the articular extremities to which important muscles and other joint-structures are attached, thus procuring free access to the joint for the removal of diseased tissue; and these fragments are then replaced and fastened with bone or ivory nails after the partial resection or arthrectomy is completed. In the knee-joint the spine of the tibia—the part to which the patellar tendon is attached—is thus temporarily detached and, later, replaced; in the hip the trochanter major is dealt with in a similar manner, and in resection of the elbow the olecranon is temporarily resected, and in the ankle-joint the malleoli are detached before and replaced and fastened after completion of the arthrectomy. I have followed Tiling's suggestion in a number of hip- and elbow- joint resections, and have been well satisfied with the operations and their results. The joint that is best adapted for arthrectomy is the knee-joint, and more than two-thirds of all the operations performed up to date were made on this joint. About two years ago Schede made a number of arthrectomies on the hip-joint through a large curved posterior incision, which enabled him to dislocate the head of the femur upon the dorsum ilii, which, after the extirpation of the capsule, he replaced. It is not probable that this operation will ever become popular, as the large resection wound, which it is necessary to make to expose the joint freely, is a serious objection in many of the cases requiring arthrectomy. I will describe here my plan of extirpating the soft structures of a tubercular knee-joint. This operation is applicable in all cases of primary synovial tuberculosis, in preference to resection, as by it the diseased tissue can be effectually removed without unnecessary loss of healthy tissues that are necessarily sacrificed by the latter operation. The immediate and ultimate success of an operation for tubercular joint affections depends largely upon the thoroughness with which the operation is done and the absence of suppuration.

Arthrectomy should be done before fistulous openings have formed, and the joint must be opened by an incision that will expose every nook and corner of the capsule. Of the many incisions that have been devised for opening the knee-joint, Volkmann's incision—the one I shall here describe—offers the greatest advantages and is open to the least objection. The old-fashioned horseshoe incision, with the convexity directed downward, makes it very difficult to suture the wound, and leaves a scar where it is most exposed to injury. The transverse incision, carried directly across the knee-joint, if the patella is divided at the same time, leaves, subsequently, the superficial and deep parts of the wound directly opposite; if the patella is preserved the scar of the external incision falls upon the most prominent part of the patella, which is again a great disadvantage. The incision which, for several years, I have always selected in opening the knee-joint, in performing arthrectomy or excision, is a curved incision, but the convexity of the curve is directed *upward*. It is carried from the most dependent portion of the knee-joint, at a point corresponding to the most prominent part of the internal condyle of the femur, in a gentle curve, to an inch above the upper border of the patella, and from here, downward and outward, to a point opposite where it was commenced. The short, semilunar, cutaneous flap is now detached and turned downward to a point corresponding with the insertion of the tendon of the patella. After this an incision is carried directly across the joint, dividing the lateral ligaments and crossing the patella transversely at its centre. The patella, at this step of the operation, is divided with a saw. The upper portion of the synovial sac is freely opened by making an incision on each side of the upper half of the patella, which is carried as far as the upper recess of the synovial sac. The rectangular flap, composed of the upper fragment of the patella, with its muscular attachments, is reflected, which exposes every portion of the upper part of the synovial recess. A somewhat similar flap is made of the lower

half of the patella, and its tendon reflected in a downward direction, by which the tissues underneath that portion of the patella and its ligaments are fully exposed. With the knee-joint thus exposed, it is not difficult to extirpate, with the help of a catch-forceps, a sharp scalpel, and a pair of curved scissors, the entire capsule. The part of the capsule that will be found most difficult to remove is that portion which covers the popliteal vessels and dips down behind the condyles of the femur and behind the tuberosities of the tibia. During this part of the operation the leg must be forcibly flexed over a small cushion, or the fist of an assistant, in the popliteal space.

Arthrectomy is always a tedious operation, as it is absolutely necessary to remove all of the infected tissues in order to secure permanent success. If the patella is not diseased it should never be removed. After the capsule has been extirpated the patella is united by two chromicized catgut sutures. I have never failed in obtaining bony union in four to six weeks after this method of coaptation. After extirpation of the capsule, and before the elastic constrictor is removed, the whole surface should be once more irrigated with a hot solution of corrosive sublimate (1 to 1000) or iodine-water, after which it is rubbed off with iodoform gauze in order to remove any detached fragments of tubercular tissue that have not been washed away. The whole surface is now freely sprinkled with impalpable iodoform, which is rubbed into the surface. Before the constrictor is removed the wound is packed with aseptic gauze, the flaps are laid over it, and manual compression made for five or ten minutes after the removal of the constrictor with the limb in an elevated position. This simple procedure serves an admirable purpose in controlling capillary hæmorrhage, and reduces the necessity of recourse to ligature to a minimum. After all the bleeding has been arrested the patella is sutured, and the deep parts of the wound are united by buried sutures of catgut. Tubular drainage can usually be dispensed with, as a capillary drain composed of a few threads of catgut will answer an excel-

lent purpose, and will not, like the tubular rubber drain, necessitate an early change of dressing. The external incision is closed with silk sutures, the line of suturing being out of the way of the patella, the parts united with the buried sutures being covered throughout by the external flap. A careful hæmostasis and rigid antiseptic precautions will make it unnecessary to change the dressing earlier than the end of the second week, and on this account I prefer to immobilize the limb in a plaster-of-Paris splint applied over a copious antiseptic dressing. The limb must be kept in an elevated position for at least six hours after the operation, so as to diminish the amount of parenchymatous hæmorrhage. If all the infected tissue has been removed and the wound remains in an aseptic condition, the external wound will be found closed in the course of two or three weeks. A fair restoration of function with partial mobility of the joint can be expected in favorable cases. Passive motion must be delayed until the patella has firmly united, which will require from three to four weeks in children and nearly twice this length of time in adults. After the patella has united and the external wound is completely healed, recovery is hastened by passive motion, massage, and the use of the faradic current. Arthrectomy has a promising future in the treatment of primary synovial tuberculosis of the knee- and elbow- joints, but for well-known anatomico-pathological reasons it is not equally applicable in the treatment of similar affections of any other of the larger joints. It is possible that the present operative technique will be modified and sufficiently perfected in the future so as to bring the hip-, ankle-, wrist-, and shoulder- joints within the limits of its present utility in the treatment of surface tuberculosis of the other large joints. In several cases of tuberculosis of the elbow-joint, I obtained an excellent result from arthrectomy combined with temporary resection of the olecranon process. This process was divided obliquely with a saw at its junction with the shaft of the ulna, and, after the extirpation of all of the infected soft tissues of the

joint, the process was fastened in its proper place,—in one case with small, aseptic, ivory nails; in the others with catgut sutures. In all of these cases the functional result was excellent, a strong arm and a fair range of motion in the joint.

CHAPTER XXVI.

Resection.

The operative removal of portions or the entire articular extremities for injury or disease is called resection. Until quite recently this operation was made by removing both articular extremities, which is now called a *complete or typical resection* to distinguish it from a more modern and conservative operation which aims only at the removal of injured or diseased portions of the articular surfaces, and is known as *partial or atypical resection.* Both of these operations have their distinct and specific indications in the treatment of tubercular affections of joints, according to the primary location and extent of the disease.

History.—The operation of resection of joints is mentioned by Hippocrates in the treatment of irreducible dislocations, and Celsus speaks of it in connection with compound dislocations. Paulus Agineta was the first to recommend excision of the articular ends of bones in certain grave cases of joint disease. This indication for resection, laid down by Agineta, was revived by Ambrose Paré.

The names of Paré, Broucher, and Thomas are intimately associated with the history of surgery pertaining to preservation of life and limb by resection of injured and diseased joints. White's famous operation was made in 1768. Bent, Orred, but especially Park, in England; Lentin and Görke, in Germany; the Moreaus and Percy, in France, were enthusiastic followers of White, and extended the operation to other joints. The application of this method of treatment to different joints was strongly urged and diligently carried out by the two Moreaus and Roux. The most distinguished and influential surgeons in France, like Dupuytren and Delpech, occasionally made a resection. Baron Larrey, Percy, Champion, and several others resorted to it even in their military practice, but the general

mass of surgeons took no interest in this subject. Later, Chassiagnac, Maisonneuve, Nélaton, and Malgaigne introduced new methods of operating, and in other ways rendered valuable service in bringing resection to the favorable notice of the profession. In England, Crampton and Syme, in 1827 and 1831, revived the almost forgotten and utterly ignored operation, but it did not gain a firm foothold until again established through the clear teachings and firm example of Ferguson (1850). In 1831 Mr. Syme ("Treatise on the Excision of Diseased Joints," 1831) called attention to the then almost obsolete operation in the following language:—

"Though amputation is a measure very disagreeable both to the patient and to the surgeon, it has, hitherto, with hardly any exception, been regarded as the only safe and efficient means for removing diseased joints which did not admit of recovery." The idea of cutting out merely the morbid parts, and leaving the sound portions of the limb, seems to have hardly ever occurred, or to have been met by so many objections that it was almost instantly abandoned. From 1830 to 1850, the operation was performed almost exclusively in Germany. Among the early advocates of this operation in that country, besides those enumerated above, should be mentioned Palm and Gräfe, followed later by Jäger, Textor, Fricke, Heine, J. F. Heyfelder, Ried, Langenbeck, A. Meyer, Stromeyer, and Esmarch. As late as 1839, Richter ("Die Organischen Knochen-Krankheiten," p. 51. Berlin, 1839) placed a very low estimate on the value of resection, as is apparent from the following quotation: "Die Resection der Knochen ist mehr als chirurgisches Knuststück, als eine Heilung bringende Operation zu betrachten, und, teils des verletzenden Eingriffs, teils der Grossen Unsicherheit des Erfolges wegen, insofern selbst beim Glücklichsten Ausgange dem Kranken immer nur ein verstümmeltes und unbrauchbares Glied erhalten wird, zu vermeiden." The valuable services rendered by men of more recent date, like Langenbeck, Volkmann, König, Kocher, and Billroth, in the development of this

department of surgery, are too well known to require more than simply mentioning their names. In Holland, Mulder established resection of joints as a legitimate surgical procedure. In Italy it was introduced by Regnoli and Sarghi. In our own country it gained a firm foothold through the labors of Mott, Rhea, Barton, Sayre, and Bauer.

Indications for Operation.—Resection of a tubercular joint is indicated when a primary osseous focus or foci cannot be reached by an extra-articular operation, when the joint has become invaded secondarily, and when a primary synovial tuberculosis has extended to the articular surfaces of the bones, and the disease has proved refractory to less heroic measures. A great discrepancy of opinion still prevails among surgeons, even at the present time, both in reference to the utility of this operation and the proper time when it should be performed. Not a few condemn operative treatment altogether, and pursue an entirely conservative plan of treatment. Others admit that resection is a justifiable operation and assign to it a limited application in their practice, but restrict it as a *dernier ressort*, in cases where the disease has far advanced or where, in consequence of it, the general condition of the patient has been seriously affected. Thus, according to Selenkow ("Zur operativen Behandlung der Tuberculose." *St. Petersburger Med. Wochenschrift*, No. 19, 1884), Pirogoff came to the conclusion that resection alone seldom accomplishes complete removal of all tubercular material, and that, consequently, a speedy return of the disease would follow unless other precautions were resorted to. A third class of surgeons regard resection, or one of its modern substitutes—arthrectomy —as the most efficient means in removing the local disease and in preventing general infection, and consequently plead in favor of early radical interference. The opponents of the operation claim that better local and general results are obtained without it, and that the operation not infrequently is the direct cause of local and general dissemination of the disease. There can be no doubt that the antiseptic treatment of wounds and improved methods of

operating which have recently been devised for different joints have not only greatly diminished the great risks of trumatic infection, but have at the same time influenced surgeons in making the operation earlier and more thorough, and thus improve the local results and greatly reduce the danger incident to traumatic infection. It is not possible to lay down cast-iron rules in pointing out the indications for resection, as both the local and general conditions must be carefully considered in each case before deciding upon the propriety or justifiability of an operation. Unless the general condition of the patient furnishes a contra-indication, it may be stated as a rule that, in all recent cases of primary synovial tuberculosis, treatment should be commenced with intra-articular and parenchymatous injections of iodoform, and, if necessary, by rest and immobilization of limb, and this treatment should be continued for some length of time before an operation is decided upon. If no improvement follow this treatment, or if, in spite of it, the symptoms become aggravated, the joint should be opened, and the conditions then revealed will point out whether an arthrectomy or a partial or complete resection should be made. Extensive deformity of the joint, regardless of the extent of the disease, indicates a resection, as this operation alone can restore partly or completely the function of the limb. Incipient pulmonary tuberculosis, developing in the course of a tubercular disease of a joint, has often been arrested by a prompt operative removal of the local disease in the joint. Age furnishes no contra-indication to the operation, although the immediate and remote results are much better in children than adults. König showed long ago that resection of tubercular joints in the aged is often followed by the most happy results.

Schlüter ("Knieresection im höheren Alter wegen Tuberculose." *Deutsche Zeitrschrift f. Chirurgie*, B. xxx, p. 285) reports 100 cases of tuberculosis of the knee-joint occurring in persons who had passed the age of 20, in which resection was performed. The operation adopted was usually that of Volk-

mann; but sometimes the joint was exposed by a curved incision below the patella. Healing, as a rule, occurred without complications, the average period being two months; in some of the cases recovery was retarded by suppuration and recurrence of the disease. The results in these cases show complete recovery in 44, 3 not improved, 11 underwent amputation, 32 died, and 10 were lost sight of. In the 44 cases where a cure was effected, recovery was still permanent ten years after the operation. The same author has also collected 187 cases of resection of the knee for tuberculosis in adults, with 30 per cent. of cures. His conclusion, in reference to resection in persons advanced in life, is that the operation gives a useful limb in 64 per cent. within half a year after the operation. Tubercular joints with open, suppurating, fistulous tracts, in the majority of cases, should be subjected to resection. The complete operative removal of all the infected tissues in suppurating tubercular joints will often arrest incipient amyloid degeneration of internal organs; but if this secondary disease is far advanced the operation will only hasten a fatal termination, and should not be attempted. It should, finally, be said that operations can often be performed successfully, and will lead to a favorable termination, in an hospital provided with all modern means of successful wound treatment, while similar operations on the same patients in private practice would almost surely prove failures. It can, therefore, be regarded, as a rule, that resection is more frequently indicated in hospital than in private practice. A great many surgeons have opposed resection in children on account of one of the well-known evil results of the operation, viz.:—

Shortening of the Limb.—Mr. Syme appears to have been the first surgeon who called attention to the occurrence of shortening after removing the epiphysial line in excision of joints, for he found that the limb of a little patient, the knee-joint of which he excised in 1830, after the lapse of time, failed to grow at a rate corresponding to that of its fellow ("Contributions to the Pathology and Practice of Surgery," p. 225). Mr. Butcher

("Memoirs on Excision of the Knee-Joint," 1856 and 1858) and other surgeons who have written on the subject of excisions seem inclined to disbelieve the fact that a cessation of growth is caused in a limb from which the epiphysial cartilages have been removed in childhood.

Mr. Page, Dr. Keith, and Mr. Jones also maintained the opinion that the removal of the epiphysial cartilages does not interfere with the normal growth of the limb. Mr. Price (*ibid.*, p. 151), after giving the result of his own clinical observations in reference to this point, continues: "I could quote various other cases, illustrating the want of adequate growth in a limb after its knee-joint has been excised at an early period of life, but I consider the above sufficient for our purpose."

Ollier ("Sur la résection de la hanche dans les coxalgies suppurées." *Lyon Médical*, No. 18, 1881. *Ibid.*, *Revue de Chirurgie*, 1881, pp. 177, 369, 548) studied, experimentally and clinically, the causes of shortening after resection of the hip-joint. He maintains that the shortening follows in consequence of removal of the upper centre of growth, the epiphysial cartilage. He asserts that the femur grows in length equally at both extremities of the bone in children under 4 years of age, but that after this time the growth of the length of the bone at the lower epiphysis is double that of the upper end; so that, while the bone grows two centimetres in length at the lower end, only one centimetre is added to the upper. He expects ultimately nine centimetres of shortening if the upper epiphysis, with cartilage, is removed in a child 4 years of age; deviation of the pelvis compensates for the shortening, even if this amounts to from seven to eight centimetres.

Julius Wolff ("Ueber Ellenbogen und Hüft gelenk-resection." *Verh. d. Deutschen Gesellschaft f. Chirurgie*, 1882) made a complete resection of the elbow-joint in a child 3 years of age, and had an opportunity to make a careful examination nine years later. The resection involved the removal of the epiphysial cartilage of all three bones entering into the forma-

tion of the elbow-joint. On accurate measurements it was found that the resected humerus was a little longer than the opposite one, and the ulna was two centimetres shorter, while the radius showed only five millimetres shortening. In a case of subtrochanteric resection of the femur, in a boy 12 years of age, he found, at the end of nine and one-half years, that the shortening amounted only to two and one-half centimetres, which would indicate that the growth of the resected bone was not impaired by the removal of one of its epiphysial cartilages. In two cases of resection of the knee-joint in children, Albrecht ("Ueber den Ausgang der fungösen Gelenk entzündungen und die Bedeutung der Gelenkresection bei solchen." *Deutsche Zeitschrift f. Chirurgie*, B. xix) found, after seven and eight years, twenty centimetres of shortening.

Tiling ("Vorschläge zur Technik der Arthrectomie resp. Resection an Schulter, Ellenbogen, Hüfte, Knie und Fussgelenk." *St. Petersburger Med. Wochenschrift*, Nos. 33, 34, 1887) reminds us that the modern methods of resecting joints have, for their main objects, to render all the joint-structures easily accessible to direct treatment and the preservation, whenever possible, of intact parts of joints which are important in securing a good functional result. He describes modifications of operations on nearly every one of the large joints, the main features of the new operation consisting in temporary resections of parts of the joint which serve as points of attachment of important ligaments and muscles. After the completion of the resection, these partially detached pieces of bone are fastened in their respective places by catgut sutures or aseptic; absorbable nails. In the knee-joint, for instance, the tibial insertion of the tendon of the patella is preserved by the temporary resection of a triangular piece of the spine of the tibia. In the hip-joint, it is suggested to detach the trochanter major, with all its important muscular insertions which afford free access to the joint, when, after the completion of the resection, the apophysis is fixed in its place with ivory nails. In the same manner the malleoli are

dealt with in operations on the ankle-joint and the epicondyles of the humerus and olecranon process of resection of the elbow-joint. There can be no doubt that in young children the removal of one or more of the epiphysial extremities of the long bones gives rise to more or less progressive shortening of the limb in nearly all cases in which the bone-producing structures are destroyed by the disease or removed by the operation. As the shortening, under such circumstances, has often amounted to several inches, and that from this source alone the patient lost the use of the limb, it is not surprising *that surgeons are aiming more and more to limit the operation to the removal of the structures outside of the epiphysial cartilage, thus preserving the centres of growth.* The practical importance and value of the suggestions made by Tiling will be appreciated more and more, as their application in resection of the different joints will do much toward diminishing extensive shortening after resection of the large joints and in obtaining otherwise better functional results.

REPRODUCTION OF JOINT-STRUCTURES AFTER RESECTION.

One of the great questions in connection with resection of joints is in reference to the extent the structures removed are reproduced after the operation. This subject has an important bearing on the functional results obtainable by the operation. This matter has received the careful attention of surgeons for more than a century, and valuable experimental and clinical studies have been made; yet a great deal remains to be done before definite conclusions can be drawn. The tendency among surgeons at the present time is to devise methods of operation which will leave the parts in a condition better adapted to reproduction of the joint-structures removed than was the case after the older operations. It is now the prevailing idea that only diseased tissue should be removed, and as little of the healthy bony structure sacrificed as is compatible with a thorough operation. This applies more particularly to operations on

joints where it is desirable to procure a movable joint in order to obtain the best functional result, as the shoulder- and elbow-joints. The first effort to study, experimentally, the reproduction of joints after resection, in a systematic manner, was made by Steinlein in 1849 ("Ueber den Heilungsprocess nach Resection der Knochen." Dissertation, Zürich, 1849).

Vermandois (*Journal de Médecine*, T. lxvi) was the first to resect the upper end of the femur, immediately below the trochanter minor, in a dog. The wound healed in two months by granulation. At this time the animal had partial use of the limb. It was killed and the new joint carefully examined. The resected end was found covered with irregular prominences of new bone, and was connected by a strong ligamentous mass with the acetabulum. The circumference of the acetabulum was diminished in size, and the cavity was filled with a red substance, which Vermandois regarded as enlarged and injected synovial glands. This experiment on the same animal was repeated later by Chaussier (*Magasin Encycloped.*, An. v, T. vi, No. 24). Koeler, like some of the earlier expermenters ("Experimenta circa regenerationem ossium." Goettingen, 1786), Wachter ("De Articulis extirpandis," etc. Groningen, 1810), and Heine (Feigel, "Chirurgischer Atlas." Würzburg, 1850) obtained substantially the same results. The results appeared to be about the same whether the wound healed by primary or secondary intention. During the first four or five weeks the limb operated on was useless, but from this time on function returned speedily, so that about the tenth week the animal made good use of it. In dogs killed two months to four years after the operation the resected end of the femur was usually found enlarged by uneven, irregular masses of bone; less frequently it presented a smooth surface, but no attempts at the formation of a new head or trochanter were observable in any of the specimens. The acetabulum was usually found deprived of its cartilaginous lining and filled in with firm connective tissue or new bone. The upper end of the femur was generally found

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near the pelvis, either opposite the acetabulum or above or behind it. The connection between the resected end of the bone and the pelvis was established by ligamentous tissue, which either represented a capsule which embraced the end of the bone on one side and on the other side was attached over a considerable surface of the pelvic bones, or, when the wound healed, by granulation in the shape of firm bands of connective tissue. If union between the resected end and the acetabulum was established by the interposition of a capsule, this often was found to contain a fluid which resembled synovia. If the end of the bone rested against the bony pelvic wall the latter showed a superficial depression for the reception of the club-shaped end of the femur. In most of the cases the limb was more or less shortened. In the experiments in which Heine removed not only the upper end of the femur, but also the acetabulum, he found, months after the operation, on making the post-mortem, the site of the articular surface of the pelvic bone covered with masses of new bone, against which the end of the femur rested without bony union having taken place. The resected surfaces were connected by a strong, fibrous capsule, which contained a serous fluid. In two complete resections of the shoulder-joint in dogs the same experimenter found, after the expiration of nearly a year, in one case the resected end rounded and connected by bands of cicatricial tissue, while in the other specimen the rounded end of the humerus rested in a corresponding circular depression of the scapula, and both were connected by a capsule, and the surfaces of the new articular ends covered by cartilage, and between the cartilage surfaces a meniscus was interposed. The same author made a complete resection of the elbow in a dog, and examined the specimen eighty-four days after the operation. The humeral end was covered with large masses of bone, representing approximately the condyles, which served as points of attachment of different muscles. The connection between the ends of the bone had become established in part by remnants of the cap-

sule and in part by muscular adhesions. He also obtained almost complete regeneration of parts—removed subperiosteally—of the lower end of the radius and ulna in dogs. Wachter examined the parts three months after such an operation, and found the new bone at the end of the radius almost as voluminous as in a normal bone, surrounded by a new and thick capsule, forming almost a perfect joint.

A. Wagner ("Ueber den Heilungs-process nach Resection und Extirpation der Knochen." Berlin, 1853) resected the head of the humerus, with or without a portion of the shaft, in nine rabbits. In most instances suppuration occurred, attended by sequestration of a ring of bone, which prolonged the healing process often for weeks and months. In nearly all of the specimens he found the resected end of the humerus enlarged and rounded by masses of new bone, and a more or less perfect capsule connecting it with the glenoid cavity of the scapula. In a number of specimens he found the inner surface of the capsule lined with pavement epithelium, but he was unable to detect evidences of the formation of new articular cartilage.

Bajardi (Virchow u. Hirsch, *Jahresbericht*, B. ii, 1882, p. 337) made numerous experiments on young dogs in order to study the reproduction of the articular extremities after subperiosteal and subcapsular resections. He found that the resected ends are reproduced to perfection, becoming gradually covered with articular cartilage. The new articular extremity is produced from the periosteum of the shaft of the bone, from the medulla, and to a lesser degree from the connective tissue which covers the sawn surface. The new formation commences in the medullary tissue in the form of embryonal connective tissue, which is transformed partly into bone and partly into cartilage. The periosteum and connective tissue take an active part, at a later stage, in the reproduction of tissue. The results obtained by experiments, in establishing the fact that partial reproduction of joints takes place after resection, have received

strong confirmation from carefully-made clinical observations, combined with post-mortem examinations.

Textor ("Ueber die Wiedererzeugung der Knochen nach Resectionen bei Menschen." Würzburg, 1843) had the unusual opportunity to examine the conditions after resections of the shoulder-joint, nineteen, eleven, and six years after the operation. In two of the specimens he found marked evidences of reproduction of bone. In one of the specimens the new bone was represented by a long process resembling somewhat the styloid process of the ulna, while in another instance the new bone deposited upon the resected end was a quarter of an inch in thickness and presented an uneven surface. One of the elevations of the new disc of bone served as a point of attachment for the long head of the biceps muscle, while another projection rested in a depressed portion of the glenoid cavity of the scapula. In the case that survived the operation nineteen years, he found a movable meniscus interposed between the new bone and the glenoid cavity. In one of his patients a new and almost perfect capsule had formed, which below embraced the upper one-fourth of the resected humerus. The meniscus was composed of the same tissue covering the new bone deposited upon the resected end of the humerus. Syme ("Treatise on the Excision of Diseased Joints." Edinburgh, 1831) verified the anatomical conditions by a careful post-mortem examination in two of his cases of resection of the shoulder-joint,—in one case six months, and in the other case ten years,—after the operation. In both of them he found the resected, rounded end of the humerus connected with the scapula by firm ligamentous tissue.

Sayre ("Specimen of Reproduction of the Hip-Joint After Exsection," etc. *Transactions of International Medical Congress*, 1881) has recorded the most perfect result obtainable in resection of the hip-joint. He had an opportunity to make a post-mortem examination on a patient who died of amyloid degeneration of the liver and kidneys three and a half years after

resection of the hip-joint, in a child 7 years of age. In spite of the persistence of a suppurating sinus, perfect regeneration of the joint-structures had taken place. Head, neck, and trochanter, as well as articular and epiphysial cartilages and capsule, were perfect. The microscopic examination made by Heitzmann corroborated the anatomical and macroscopical appearances.

Textor (*ibid.*, p. 13) describes an elbow-joint which formed after resection, as follows: "The ulna was elongated one quarter of an inch, upon which the radius revolved as in a normal joint. The trochlea of the humerus was as perfect as though the lower end of this bone had never been removed." In this specimen the triceps muscle was found firmly united with the cicatrix in the skin.

Ollier examined anatomically a new elbow-joint eight years after resection. The patient was 27 years old when the operation was performed, and died eight years later. He found the articular ends fully as well developed as in the intact joint, and covered by a thin layer of chondroid substance in place of articular cartilage. The synovial membrane had been reproduced and showed several compartments, while the capsule was as perfect as that of a normal joint. The function of the joint was nearly perfect. J. Wolff ("Ueber einen Fall von Ellenbogen gelenk-Resection, nebst Bemerkungen über die Frage von den End resultaten der Gelenk resectionen." *Archiv f. klin. Chirurgie*, B. xx, p. 771) made a complete resection of an elbow-joint in a child $2\frac{3}{4}$ years of age, and three years later was able to satisfy himself—from the almost complete restoration of function which had taken place and a careful examination of the arm—that an almost perfect joint had formed, including the reproduction of the olecranon process and the head of the radius. A. Wagner, and to a lesser degree, Ollier, had doubted that such a perfect result could be obtained. This case and others prove conclusively that under favorable circumstances almost perfect reproduction of the parts removed can take place. Reliable cases of almost complete restoration of the shoulder-joint after

resection have been reported by Luecke; of the ankle-joint, by Doutrelepont, Heinemann, Czerny, Jagetho, and Weichselbaum; of the elbow-joint, by Syme and Textor. Two forms of joints have been described as observed after resection of the elbow-joint. In the first variety the olecranon is not reproduced, or it exists only in a rudimentary form. In such a case the sigmoid cavity of the ulna and the trochlea of the humerus are absent. Lateral deviation of the forearm during flexion and extension is prevented by the condyles of the humerus, which are well developed and embrace the convex end of one or both bones of the forearm. Such a result has been described by Syme, Czerny, Jagetho, and, perhaps, Ollier's case belongs in the same category. In the second variety the restoration of the structure and function approaches more nearly a perfect joint. The olecranon process of the ulna and trochlea of the humerus are almost perfect,—conditions which insure an almost perfect ginglymus joint. Preservation of periosteum and other structures of the joint, not affected by the disease or injury which has made the operation necessary, is an essential factor in obtaining restoration of structure and function approaching a perfect joint.

CHAPTER XXVII.

Atypical and Typical Resection.

In the treatment of tubercular joints in children, atypical will more and more take the place of typical resection. If, by this operation, a good and useful position of the limb can be obtained and all of the diseased tissues can be removed, it seems to me it is the ideal operation for all cases in which the capsule and a part of the articular surfaces require operative removal. As to the question of typical resection, with sawing off of the entire ends of the articular extremities of the bones, Mr. Barker (*British Medical Journal*, June, 1888) predicts that, after a few years, when the principles underlying the treatment of tubercular disease are better understood and the necessity of early operation will be more generally recognized, such operations will be some of the rarest in surgery, and will be replaced entirely by the extirpation of localized foci in the bones, without any sacrifice of their length and growing power. The external incision in atypical and typical resection of joints should be the same. *Incisions which procure most ready access to all parts of the joint and that interfere least with the attachment of important muscles should be selected.* It is often only after the joint has been opened by such an incision that the surgeon is in a position to make an intelligent choice between arthrectomy, atypical and typical resection. In operating on the knee-joint after the external incision is made the patella is divided transversely, and, if it does not contain a tubercular focus, it is not necessary or advisable to remove this bone, as its continuity, after resection, can be restored by suturing with a durable form of catgut. *An atypical resection for tuberculosis consists in extirpation of the tubercular capsule and of the removal of tubercular foci in the epiphysial extremities of the bones that enter into the formation of the joint, without removing the entire articular extremities by a transverse section with the saw.*

The unnecessary removal of the epiphysial extremities should especially be avoided in the case of young children, as the removal of one or both centres of growth of bone will result only too often in so much shortening of the limb subsequently as to render it not only perfectly useless, but it becomes frequently, at the same time, a burdensome appendage. *In children atypical resection should be practiced in all cases where all the foci in the articular extremities can be reached and removed by this method.* The proper instruments to be used in this operation are the chisel, bone-forceps, sharp spoon, catch-forceps, and curved scissors. After the joint has been freely opened the articular surfaces are carefully inspected for evidences of superficial and deeply-seated osseous foci. In primary synovial tuberculosis, with circumscribed superficial erosions of the bone, the latter are to be scooped out thoroughly by free use of the sharp spoon. If perforation into the joint from an osseous focus has taken place the cavity is freely exposed from the articular surface, and all of the infected tissues are removed with chisel and sharp spoon. It is important not only to remove necrosed bone, granulation tissue, and caseous material, but also the surrounding osteoporotic zone of bone that possibly might contain tubercle bacilli. A deep-seated focus may be suspected, and should be searched for, if the articular cartilage has become detached over a greater or less extent. Explorations with a small perforator can be made in different directions from the articular surface in searching for deeply-seated foci. *A circumscribed area of great vascularity is a suspicious indication, and calls for a limited excavation, with a sharp, small spoon, for diagnostic purposes.* It is well for the surgeon to remember that primary osteotuberculosis, with secondary involvement of a joint, usually consists of more than one focus in one or both articular extremities. A tubercular infarct is generally recognized by examining the articular surface, as the cartilage or the exposed portion of the wedge-shaped sequestrum presents typical appearances of necrosis that

cannot be mistaken. After the extraction of the sequestrum the tubercular cavity is subjected to the same treatment as when dealing with a granulating or caseous focus. If the pathological conditions are such as to require removal of one of the condyles of the femur, or one of the tuberosities of the tibia beyond the epiphysial line, in resection of the knee-joint, the operation need not consist in making a complete resection of the articular extremity, as a better functional result can be obtained by removing from the opposite bone and side of the articular extremity a section of bone corresponding in size and depth to the part of the articular extremity on the side where the section was made. The resected ends then overlap each other, and a firm, bony union can be confidently expected.

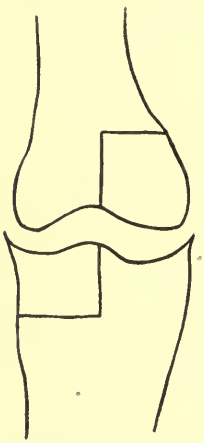

FIG. 37.—ATYPICAL RESECTION OF KNEE-JOINT, WITH SPLICING OF ARTICULAR ENDS.

By following this plan the resected ends are spliced, as it were, thus securing a large surface of bone for coaptation and the formation of a firm, bony union, in good position of the limb, without removing the entire epiphysial centre of growth of either of the bones. I have adopted this plan in several cases of atypical resection of the knee-joint, and the operation was always followed by good operative and functional results.

In primary synovial tuberculosis, with extension of the disease to the subjacent bone, it becomes necessary to remove the honey-combed, softened bone over the entire surface affected, with sharp spoon and chisel. Before the operation is extended to the bone in osteotuberculosis requiring atypical resection, it is always necessary first to extirpate, with knife and scissors, the infected soft structures of the joint, the synovial membrane, and ligaments, as otherwise the healthy vascular bone may become an infection-atrium for traumatic dissemination,—a not very infrequent and serious complication after operations on bones and joints for tubercular affections. Carti-

lage that remains firmly attached to the bone may be left. After all foci have been radically eliminated the field of operation is flushed with an antiseptic solution, and, after drying and iodoformization, the bone-cavities are packed with decalcified antiseptic bone-chips, and the operation is completed in the same manner as in arthrectomy.

I always use iodine-water made by adding tincture of iodine to sterilized water until the solution represents in color dark sherry-wine. This preparation was used long ago by Pirogoff (Selenkow, "Zur operativen Behandlung der Tuberculose." *St. Petersburger Med. Wochenscrift*, No. 19, 1884), who employed a 10-per-cent. solution of iodine, which he injected through the drainage-tubes after the resection wound was sutured. This injection he repeated in from three to four days. Since he resorted to this method of disinfection the results of the resections in the hands of this distinguished surgeon were much more satisfactory. The treatment of bone-cavities with decalcified bone-packing is of the greatest utility in atypical resection. An atypical resection with subsequent implantation of decalcified bone has for its object complete removal of the infected tissues in the joint and the surrounding bone, and the partial restoration of the parts destroyed by disease or removed during the operation. In atypical resection of the knee-joint it is not uncommon that nearly an entire condyle of the femur or tuberosity of the tibia must be removed. If in such cases the external compact layer of bone can be preserved, this should be done and bony union in good position secured,—a result which can be accomplished in the most satisfactory manner by placing the parts in a condition to repair the lost bone-tissue, which can be done by filling the defect with decalcified bone-chips. I have repeatedly made excavations in one of the condyles of the femur and in the head of the tibia from the joint surface, the size of a small orange, and obtained bony union, with the limb in a good position, by filling the cavities with bone-chips, and the time required to obtain consolidation of the articular ends

and the restoration of lost bone-tissue did not exceed the time necessary to unite a subcutaneous fracture in the upper portion of the tibia or the lower part of the femur. As the bone-chips are always iodoformized before implantation, they serve a useful purpose, not only by furnishing a temporary scaffolding for the reparative material, but they constitute at the same time a valuable therapeutic measure, in the prevention of a local recurrence of the disease in case tubercle bacilli should remain in the cavity or its immediate vicinity. At the same time the bone-packing serves the purpose of an absorbable tampon, which prevents excessive oozing from the cavity after the operation. A capillary drain inserted into the outer and inner angle of the wound will answer the purpose of drainage. Immobilization of the limb after resection should be continued until the process of repair has been completed, which, under the most favorable conditions, requires from six weeks to two months. Atypical resections are applicable only to certain joints,—as the knee, elbow, and, to a lesser extent, the ankle, tarsal, and carpal joints. The elbow-joint is most accessible through a long, straight, posterior incision, and after temporary resection of the olecranon process. Partial resection of the ankle-joint can be done through two lateral incisions, with chisel and sharp spoon. In all resections, atypical and typical, ignipuncture is indicated after the excision has been completed if any portion of the bone is abnormally osteoporotic, as this procedure will stimulate the process of repair, and may prove useful in destroying infected tissues, which, from their macroscopical appearance, indicate a healthy condition.

Typical Resection.—In typical or complete resection the synovial membrane and ligaments of the joint are extirpated completely; at the same time, one or both articular extremities are sawn across and removed. In the hip-joint this operation, aside from the extirpation of the soft structures of the joint, aims at the removal of the head, neck, and part or the whole of the greater trochanter of the femur. A typical resection of the

wrist-joint implies the removal of the entire carpus, with or without the articular surfaces of the radius, ulna, and metacarpal bones. In a complete resection of the shoulder-joint the head of the humerus is removed. In the knee-joint the same operation implies excision of the articular surfaces of the femur

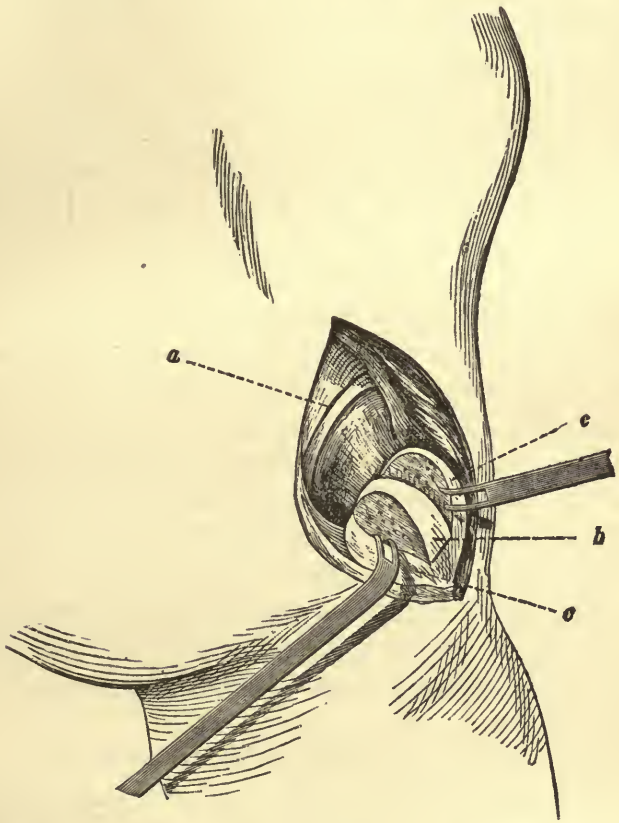

FIG. 38.—KÖNIG'S OPERATION OF RESECTION OF THE HIP-JOINT.

c c, the two trochanteric borders separated and turned away from the bone; *b*, central of trochanter, which is to be removed by cutting toward the base of the neck of the femur.

and tibia; in the elbow-joint, of the humerus, radius, and ulna; in the ankle, of the tibia, fibula, and astragalus. Typical resections are generally made for tubercular affections of the shoulder-, hip-, and wrist- joints. In the remaining large joints it is more frequently resorted to in adults than children. In children the

operation is limited, with the exception of the shoulder-, hip-, and wrist- joints, to cases where the articular extremities are so extensively diseased that an atypical resection would fail in removing all of the infected tissues. Extirpation of the diseased synovial membrane and ligaments should precede section of the bones with the saw or chisel whenever, from the anatomical construction of the joint, this can be done. In the hip- and shoulder- joints the head of the bone must be removed first before the soft structures of the joint can be extirpated. One of the best adapted operations for resection of the hip-joint is the one devised by König, by which the anterior and posterior borders of the trochanter major are preserved. In this operation the section of the bone must be made with a chisel. The entire head and neck of the femur are removed by dividing the bone transversely with a chisel just below the neck, with the exception of the borders of the great trochanter, which are split off with the same instrument.

The capsular ligament is removed as thoroughly as possible, and the acetabulum is scraped out with a sharp spoon. Provision for drainage must be made in all hip-joint resections.

In order to prevent accumulation of blood in resection wounds, and for the purpose of securing more thorough iodoformization of the surfaces, it has recently been customary, especially in Germany, to resort to iodoform tamponade and secondary suture.

Bramann ("Ueber Wundbehandlung mit Iodoform tamponade." *Archiv f. klinische Chirurgie*, B. xxxvi, p. 72) has published the results of this modification of wound treatment in resection of joints from April, 1884, to end of July, 1886. The iodoform-gauze tampon is made large enough to exert gentle pressure against the surfaces of the wound, and is allowed to remain from two to three days, when it is removed and the wound sutured and dressed in the usual manner.

Resection of Hip-Joint (*Thirty-four Cases*).—Tampon removed after forty-eight hours. No death from immediate effect

of operation. Final result not known, 6; cured, 21; discharged with fistula, 4; died later, wound healed, 2; died later, wound not healed, 1.

Resection of Knee-Joint and Arthrectomy (*Twenty-one Cases*).—Tampon removed and wound sutured after two to three days. Cured, 16; result not known, 1; discharged with fistula, 2; three deaths, six to eighteen months later, from pulmonary phthisis; cured later, 1; died, 1. In most cases recovery with ankylosis.

Resection of Ankle-Joint (*Eight Cases*).—Cured, 1; amputated later, 3; wound not healed, and death from pulmonary tuberculosis several months after operation, 4.

Resection of Shoulder-Joint (*Three Cases*).—Cured (children), 2; died, patient 60 years old, three weeks later, from pulmonary phthisis, 1.

Resection of Elbow-Joint (*Eleven Cases*).—Discharged cured, 6; discharged with fistula, 4; chloroform death, 1. Final result: Cured, 7; wound not healed, 2; died, 2; functional result in three cases excellent.

Resection of Wrist-Joint (*Two Cases*).—In both cases wound healed, but functional result imperfect. Helferich ("Die praktische Bedeutung der Sekundären Naht." *Münch. Med. Wochenschrift*, Nos. 20, 21, 1887), although in favor of this method of treatment, objects to the tampon and secondary suture in resection of the knee-joint. At the last meeting of the International Medical Congress, von Bergmann presented, in the Surgical Section, a number of cases that had recently been operated on by this method, and every one who had the privilege of seeing the cases and of listening to the remarks of this distinguished surgeon became convinced of its merits. It is more especially useful in the treatment of resection wounds in which it is impossible to prevent "dead spaces" by suturing. I am in accord with Helferich in advising against its employment in resection of knee-joint, as in such cases the wound surfaces can and should be brought in permanent and uninterrupted

contact immediately after the excision, and the parts should be disturbed as little as possible subsequently.

Bramann mentions, as one of the disadvantages of this treatment, the necessity of placing the patient under the influence of anæsthesia at the first dressing. This objection I have overcome by introducing the sutures at the time of operation and tying the ends loosely together over the dressing. The removal of the gauze and tying of the sutures can be done without anæsthesia. The after-treatment, in excision of the hip by this method, consists of rest in bed upon a smooth mattress, with the limb extended by weight and pulley in an *abducted* position. After six weeks the patient is allowed to walk on crutches, with a raised sole under the shoe, worn on the opposite side, so that the limb on the resected side swings freely and makes the necessary auto-extension. During the night extension is kept up for eight months or a year, in order to prevent unnecessary shortening. Eversion and inversion of the limb while the patient is in bed are prevented either by a Volkmann railway-splint, or by supporting the limb with sand-bags, applied to each side. Immobilization, after resection of the shoulder-, elbow-, wrist-, knee-, and ankle- joints, is best secured in a plaster-of-Paris dressing, which also serves an excellent purpose in keeping the antiseptic dressing *in situ*. Instead of a circular splint, a posterior splint made of the same material can be made, as advised by Sayre and others. Temporary resection of the olecranon process, in excision of the elbow-joint, has yielded excellent results in my hands, as by it the insertion of the triceps muscle is not disturbed. The resected olecranon, after the removal of any foci it may contain, is riveted to a denuded surface of the shaft of the ulna with a sterilized ivory or bone nail after the resection has been completed, or it is fastened with two durable catgut sutures. The latter method of coaptation and fixation I employ now almost exclusively. The forearm is immobilized in a semiflexed position until bony union between the shaft of the ulna and olecranon process has taken place, which usually

requires from four to six weeks. After this time, passive motion and massage should be made to increase the mobility of the joint. A straight, single incision upon the posterior side, directly over the centre of the olecranon process, is the one which affords best access to the elbow-joint, with the least injury to the tissues around the joint. A straight, single incision upon the dorsal side is best adapted for resection of the wrist-joint, as the extensor tendons of the hand and fingers can be drawn aside sufficiently to afford ample room for the removal of the entire carpus. In the after-treatment of excision of the wrist, the forearm and hand, as far as the metacarpo-phalangeal joints, are encased in a plaster-of-Paris splint, with the hand in a slightly extended position and half-way between pronation and supination.

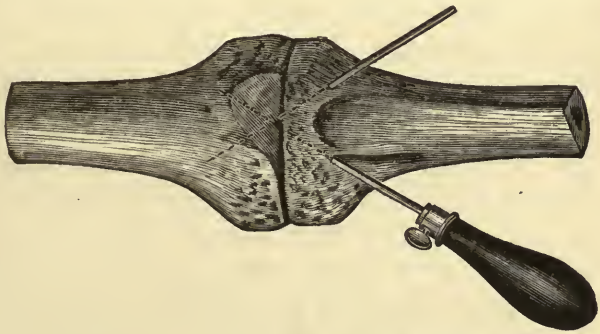

FIG. 39.—BAKER'S PINS TO HOLD BONE SURFACES IN APPOSITION. (*Brit. Med. Journal.*)

Immediate fixation of the resected ends by means of aseptic bone or ivory nails, after excision of the knee or any other joint, is superfluous, as the parts can be kept in accurate position by ordinary external fixation dressings. In knee-joint resections, the section through the bones must be made in such a manner that when the sawn surfaces are brought in apposition the leg will be sligtly flexed, as this position enables the patient to walk more easily and gracefully than with a straight, stiff limb. The artificial support must not be removed until firm, bony union has taken place, which will require from two to three months, according to the patient's general health and age.

CHAPTER XXVIII.

Immediate and Remote Results of Resection.

The value of all surgical interventions in the treatment of articular tuberculosis is estimated differently by different surgeons. The immediate and remote results depend largely upon the time the operation is made and the thoroughness with which it is executed. I recollect that one of the best surgeons of Germany made the statement to me, a few years ago, that the results of his operations for tubercular affections had been greatly bettered since he had been on a visit to Bardenheuer and had witnessed the operations of this bold surgeon for different forms of surgical tuberculosis, notably excision of joints. The operative result, like in operations for malignant disease, will be better from year to year, as surgeons are becoming more and more convinced of the necessity of early interference and of thorough operating. I think every surgeon of large experience would have to admit that the results of his early operations do not compare favorably with those obtained later, as his experience increased. In order to present to the reader the different prevailing views in regard to the immediate and remote results of resection of joints for tuberculosis, I will quote authorities from different countries and statistics from various sources. In 1880 Mr. Holmes, in his address on surgery, before the British Medical Association, referred to 245 resections of the knee, done in seven of the largest hospitals in London, with a mortality of 21; failures, 47; of which latter 36 were subjected to amputation; and recoveries, 173. Of 215 hip-joint resections 40 died, 57 proved failures, and 118 recovered.

Wartmann (*Deutsche Zeitschrift f. Chirurgie*, B. xxiv, p. 435, 1887), after giving a careful account of the results following excision of tubercular joints in the hospital practice of Feurer, gives the statistics of 837 cases of excision of joints for tuberculosis, from the practice of different operators. Of this

number 225 died. Of the fatal cases, in 26 death followed the operations closely, and resulted from acute tuberculosis, probably induced by the operation. Schmid-Monnard ("Ueber den Zeitrunkt für Bestimmung endgültiger Resultate der Resection tuberculös erkrankter Gelenke." *Centralblatt f. Chirurgie*, No. 52, 1889) has collected from several large clinics cases of joint resection, which had been followed from two and one-fourth to fourteen years after the operation, for the purpose of ascertaining the final results and the causes and time of death of the fatal cases. Most of the operations were done since the antiseptic treatment of wounds has been in vogue. He collected 116 deaths, and from the tabulated cases it can be seen that 80 per cent. of this number died within two years after the operation and the balance within five and one-half years, with the exception of 2 cases, in one of which death resulted in six and in the other nine years after the resection. *Deaths from tuberculosis diminish in frequency with the time elapsed since operation.* After the expiration of two and one-fourth years probably only 4 per cent. of all those operated on die of tuberculosis or its immediate consequences. The results *quod vitam* at this time are nearly final. Of 2207 operations, collected indifferently from the hospitals di Midi, Pitie, Necker, and Hôtel Dieu, by Thiéry ("Traitement Chirurgical des Tuberculoses Periphériques suites immediates." *Études expérimentales et Cliniques sur la Tuberculose*, 1888–1890, p. 630), 262 were performed for local tubercular affections, and of these 107 were done for tubercular diseases of bones or joints. These cases were divided as follows:—

Humbert,	523	43
Polaillon,	981	109
Le Fort,	210	35
Verneuil,	492	75
Total,	2206	262

The above cases were from and including 1886 to 1890. Two hundred and sixty-two were tubercular, with the following post-operative results: cured, 86; improved, 92; stationary,

56; local aggravation, 8; general infection, tubercular meningitis, 6; remaining in hospitals under treatment, 3; or, in other words: result satisfactory, 178 (22 mediocre); no benefit from operation, 56; aggravation of disease, local or general, 39 (14 of these died). The opinions of French surgeons on the value of the operative treatment of peripheral tubercular affections were reflected at a meeting of the Tuberculosis Congress, when Verneuil said: "We have reason to be optimistic when it concerns immediate results."

Ollier: "The most favorable cases of latent tuberculosis—this chronic, prolonged tuberculosis—would have more than one analogy with osteomyelitis; . . . . and it is known that operative treatment often proves of permanent benefit in these cases."

Demosthène made 281 operations for tubercular disease, with a mortality of 4 per cent.; the immediate results are always favorable; the remote results are as yet unknown. Bousquet has always noted a material improvement of the general health of the patients subjected to surgical treatment. Mollière, Houzel, and Queirel favor operative treatment in all proper cases. Routier, after giving his statistics, expressed himself as being convinced of the harmlessness and utility of operative procedures, and has always noticed that the general health of the patients improved after them. Le Dentu is in favor of surgical treatment and claims that the attacks of tubercular meningitis which occasionally appear to be provoked by operations are only a rare coincidence. Boeckel's work in this department of surgery has been quite extensive, and dates back more than fourteen years; it includes 53 amputations and 151 resections,—in all 204 operations; mortality, 8 per cent. after amputation and 12 per cent. after resection. Of 16 deaths occurring soon after operation, 9 were from tuberculosis; of 14 deaths in which the interval between the operation and fatal termination was longer, 11 died of tuberculosis and the remainder of pneumonia and albuminuria. Schwartz gave his

opinion, based on 200 operations that he performed, that in all but one the immediate effects were favorable; in this case death from acute pulmonary tuberculosis followed a short time after the removal of a tubercular testicle. Leonté, in his 68 operations, had one death from acute miliary tuberculosis soon after a resection of a tubercular knee-joint. In reference to recurrence of the disease after operation he says: "The relapse constitutes a rock against which almost inevitably all our efforts are broken in the struggle against local tuberculosis."

Leroux's thesis (1879) gives an account of twenty-four cases whose general condition was aggravated by the operation, and Thiéry (*ibid.*, p. 637) adds four new cases.

At the Congress of French Surgeons, in 1889, Le Dentu reported several cases of multiple tuberculosis in which the operative removal of the primary focus resulted in disappearance of the remaining lesions and a permanent cure. Thiéry is of the opinion that the removal of the primary depot protects the organism against ulterior visceral diseases, of which the peripheral tuberculosis would have been the point of departure.

At the same Congress, Iscovesco said in substance: "Hasty operative intervention cannot be justified if it is intended for total suppression of every source of infection. Besides, the frequency of secondary infection is certainly exaggerated, and successive infections are wholly ignored."

Valude, a firm supporter of surgical treatment of peripheral tuberculosis, maintained that, without such intervention, the disease would become general in the majority of cases. The remote results of operative interference for tubercular affections are more gloomy than the immediate effects of the operations, according to the writings of Thiéry ("De la Tuberculose Chirurgicale," etc. Paris, 1890, p. 389 *et sequi*) and his quotations from other French surgeons. While the immediate results following the surgical intervention in local or localized tuberculosis of the bones and joints are, speaking from an operative point of view, generally satisfactory, the remote conse-

quences are less encouraging, and in the large majority of cases but few, very few, patients are exempt from local recurrence or the appearance of the disease in other parts of the body. Thiéry has traced the final outcome for two to four years in thirty-three cases operated on for bone or joint tuberculosis, to wit: Bones of extremities, 7; mastoid, 2; costo-sternal articulations, 3; shoulder-joint, 1; elbow, 4; wrist, 1; hip, 2; knee, 1; foot, 6; vertebræ, 4; synovial tuberculosis, 2. In 15 additional cases the treatment consisted exclusively of the internal administration of drugs and other measures to improve the general health. Of these 48 cases the remote results were: cured, 26; improved, 12; stationary, 11; local aggravation, 2; local relapse, 26; relapse *à distance*, 13; death from pulmonary tuberculosis, 8. Verneuil expressed himself on this point as follows: "Permanent favorable results are rare. The tubercular process, checked for a time by the operation, is very prone to resume its course, and patients operated on for tubercular affections never reach old age."

Ollier did not follow his thirty-two cases of excision of the astragalus long enough to formulate definite conclusions in reference to the permanent value of the operation. Demosthène, Mollière, Routier, and Le Dentu speak encouragingly of the remote results of their joint resections for tuberculosis. In reference to amputations as a curative measure, Boeckel gives his experience, which comprises 17 operations done for tuberculosis of the large joints, of which 16 recovered, patients remaining well, at the time the report was made, from nine to fourteen years. At the same time he relates 127 resections, including all of the large joints, of which 111 recovered and 12 died,—a mortality of 6 per cent. The remote results of these are interesting: 16 deaths soon after operation, of which 9 occurred from tuberculosis, and 14 late deaths, of which 11 could be attributed to tuberculosis; of 24 various bone resections there were 15 permanent recoveries and 9 delayed deaths. He believes that resection is a less dangerous operation than ampu-

tation in the treatment of tubercular affections of the extremities. In 10 resections of the knee, made by Schwartz, local recurrence, calling for a second operation, amputation, or *grattage*, occurred three times. The French surgeons are almost unanimous in the opinion that the immediate results of operative interference in the treatment of tubercular affections of bones and joints are, as a rule, favorable, but that the prognosis in regard to the *ultimate* benefit of resection and amputation is not equally satisfactory. Vargas, of Madrid, is opposed to the idea that the operative removal of tubercular lesions of bones and joints is ever followed by traumatic dissemination or any remote ill consequences. He is of the opinion that such attempts are instrumental not only in bringing about a local cure, but are equally efficient in protecting the organism against general infection. In support of these assertions he cites 114 cases from the practice of Rivera, Surgeon-in-Chief of the Hospital of the Infant Jesus, and 200 cases of osseous, articular, and glandular tuberculosis of Alabern, who found tubercle bacilli in all cases, and in which no post-operative lesions developed, except in 2 cases, where the operation was deferred too long, and in 5 cases that were not subjected to surgical treatment.

Korff ("Ueber die Endresultate der Gelenk Resectionen." *Deutsche Zeitschrift f. Chirurgie*, B. xxii, p. 149) reports the final results in 104 cases of resection, of mostly the larger joints, with a mortality of 39,—34 of tuberculosis,—and of these, in 7 the resection wound had already been healed. In 3 cases that died of tuberculosis amputation was made after the resection proved a failure. The American surgeons, as a whole, believe in the curative and prophylactic efficacy of operative treatment of tubercular affections of bones and joints, and quite a number of them are ardent supporters of early radical treatment, notably among them Mynter ("Is Early Resection or Conservative Treatment Advisable in Coxitis?" *Journal American Medical Association*, July 26, 1891). This surgeon reports several cases where he made resection a few weeks after begin-

ning of the joint-lesion, found well-marked pathological conditions, and obtained good results. One of the gravest objections to operative treatment of tubercular affections of bone and joints has been that, at least in rare cases, operations of this kind have been followed, within a few days to a few weeks, by

TRAUMATIC DISSEMINATION OF THE TUBERCULAR PROCESS.

By this expression is meant re-infection of the organism from the focus disturbed by the operation, and a speedy fatal termination, resulting from acute, general miliary, or pulmonary tuberculosis, or tubercular meningitis. König observed sixteen cases in his own practice in which miliary tuberculosis followed within a few days after operations on bones and joints for tubercular affections. He states that the secondary, or re-infection, sets in seven to ten days after operation, which may have been perfectly aseptic, with healing of the wound by primary union. The re-infection caused by the trauma inflicted by the operation appears either as an acute, general miliary, or pulmonary tuberculosis, or tubercular meningitis, terminating in death three or four weeks after the operation. Rapid generalization of tuberculosis, following operations destined to eradicate or suppress a localized tubercular process, has been repeatedly observed. Demars and Verneuil reported a number of such cases; but no one can foresee or anticipate such a sequela in any patient operated upon. This complication comes sooner in one than in another. Nothing announces the impending danger,—neither the variety nor the local progress, nor the patient's condition before the operation, nor the extent or severity of the operation. The pathogenesis of these cases is explained by Verneuil (*Études sur la tuberculose*, fascicule i, p. 238) as follows: "When we operate on an infected focus, be it osseous, articular, serous surface, glandular, etc., there is great danger from auto-infection from this disturbed local hearth; for the imprisoned microbes in the *loco dolenti*, being liberated by the

traumatism, may enter the blood-current, and are deposited in various organs, as the lungs, envelopes of brain, serosa, etc., where they form secondary depots, more or less numerous and important." While this auto-infection is certainly possible, this source of danger has been greatly overestimated, for, if proper precautions are practiced, it is certainly one of the rarest wound complications in such cases. *The danger arising from this source is greater in scraping operations on bones and joints than in resection or amputation.* Cases of acute pulmonary tuberculosis developing shortly after operations for tubercular affections have been reported by Demars, Verneuil, Vérchère, Metaxas, and others. Thiéry (*ibid.*, p. 175) cites a number of illustrative cases. Hygroma præpatellaris tuberculosa. General health very good; no pulmonary lesions. Incision; grattage. Ten days later, hæmoptysis; death in twenty-five days. Autopsy: "Granulie pulmonaire." Old coxitis; "redressement," and immobilization in silicate dressing. Tubercular meningitis a few days later takes a chronic course. Shortly after, general miliary tuberculosis and death. Tubercular gonitis; no pulmonary tuberculosis; redressement. Within a few days, acute pulmonary and general tuberculosis (Szuman). Tibio-tarsal tubercular arthritis. Tubercular meningitis on sixth day after operation, and death on the seventh. Old and recent pulmonary tuberculosis (Socin and Keser, *Jahresbericht über die Chir. Abtheilung zu Basel*, 1884, p. 136). Daremberg studied the susceptibility of the meninges of the brain to tubercular infection experimentally ("Notes sur la Méningite tuberculeuse expérimentale." *Étude sur la tuberculose*, p. 530). He ascertained that death was regularly produced in rabbits in from twenty-one to thirty days, from tubercular meningitis, after direct inoculation with tubercular material. The symptoms resembled those which characterize the disease in man,—paralysis, general hemiplegia, loss of vision and hearing, acute cries upon slightest disturbance. The pathological changes in the meninges resembled closely those found in the cadaver of per-

sons who succumbed to this disease. While the liver of these animals presented no macroscopical tubercular lesions, numerous bacilli were found in that organ by the aid of the microscope. Guinea-pigs inoculated in the same manner also died in from twenty-one to thirty days, from acute tuberculosis; but the meninges of the brain showed no signs of disease. It appears from this that in these animals no localization occurred in the meninges, the disease assuming, from the beginning, a diffuse form. These experiments demonstrate that infection of the meninges of the brain is almost sure to give rise to diffuse tuberculosis, provided the animal's life is sufficiently prolonged. A chicken and pigeon, inoculated in the same way, through a small opening in the skull, died in six and seven months, from tubercular meningitis, and the autopsy showed, at the same time, tubercles in the liver,—a proof that in these animals a longer time was required to produce the disease artificially than in rabbits and guinea-pigs. That meningitis may occur after an accidental or intentional trauma in a tubercular individual has been known for a long time, and the laity even understand the possibility of this source of danger following violence in children. Many a sorrowing mother has attributed the fatal disease to a fall or blow upon the head.

This subject was thoroughly discussed, from a scientific surgical stand-point, in the Société de Chirurgie, in 1883, by Verneuil, Trélat, Berger, Richelot, Desprès, and others, and it was admitted on all sides that tubercular meningitis could develop after the slightest surgical intervention in the treatment of tubercular affections; but the question whether this complication is a mere coincidence or the result of operation was not then, and has not since been, definitely settled. In some cases the cerebral affection appears already within the first twenty-four hours after the operation, the prominent symptoms being a chill, high temperature, headache, and obstinate vomiting; but in the majority of cases the patient progresses favorably for ten or twenty-five days, and then, without premonition, the brain

symptoms appear, while in a relatively small number of patients the meningeal complication is more remote. One, two, or more months may pass by, the wound in the meantime having completely healed, when suddenly these late meningeal symptoms appear, and life is destroyed in a few days from this cause alone. The autopsy reveals a diffuse recent meningitis, for which no other cause but the primary focus for which the operation was made can be found. The blood-vessels and lymphatics along the chiasma and the envelopes at the base of the brain are studded with young granulations, radiating irregularly or in disseminated groups in the fissure of Sylvius. Chantemesse has observed heaps of granulations in patches in adults, and Metaxas and Vérchère (*Étude sur la tuberculose*, page 535 *et seq.*) have more rarely observed thickened pia matter with purulent appearance, rarely due to softened tubercles, as described and found in cases of tubercular meningitis in children. These anatomical lesions, so acute, numerous, and diffuse, point directly to the true source and nature of the determining cause. It is not essential that the operation should have been made on a tubercular focus in the causation of a traumatic tubercular meningitis, as this lesion may develop in a tubercular subject after a fall on the head, a blow, a contusion; but, as a rule, it develops as a *post-operationem* result.

Chantemesse (*Thèse de Paris*, p. 165, Obs. 46) has found, as one of the conditions of traumatic tubercular meningitis, the remains of a similar lesion, from which the patient had recovered completely years before the appearance of the second attack,—due to traumatism or surgical intervention for other tubercular lesions. Therefore, post-operative meningitis may be a primary lesion in an otherwise healthy person, but predisposed to tuberculosis from hereditary or acquired infection; it more frequently occurs in the tubercular with manifest visceral or peripheral lesions. Of these the latent meningeal localizations are the most dangerous and cause a second acute attack most rapidly. The disease is most prone to follow operations on tubercular bones

or joints, and scraping of tubercular affections of the soft parts. Pathological anatomy has shown that the meningitis is recent, and that the lesions present appearances which do not date farther back than the operation. Serous surfaces, and among them the meninges of the brain, are favorite localities in which tubercle bacilli that have entered the general circulation become localized, and in which they exercise their specific pathogenic properties. During an operation for tuberculosis some of the bacilli may find their way into the blood-current, and, if they accumulate in the envelopes of the brain in sufficient number, they give rise to secondary disease in these structures.

Metaxas and Vérchère have collected 55 cases of meningitis following operations, with the following result: Resection, 18 times; amputation, 6; grattage of abscesses or fungosities, 11; tuberculosis of spine, 3; évidements for tuberculosis in other localities, 2; incomplete removal of tubercular testicle, 2; extirpation of tubercular glands, 3. In 2 cases the disease followed ignipuncture of tubercular joints, and once it could be traced to débridement of the nasal cavity. These authors claim that more than half of the cases of tubercular meningitis are caused by operations for tubercular disease of bone, and they conclude their valuable paper on this subject by placing on record the following cases:—

Case I. Boy 14 years old; coxitis. Resection. Perforation acetabulum. Death from tubercular meningitis seven months later. A few tubercles in lung, liver, and spleen.

Case II. Boy 2 years old; abscess behind left trochanter major. Excision of hip-joint; joint very extensively affected. Death from tubercular meningitis sixty-six days after operation.

Case III. Boy $7\frac{1}{2}$ years old; disease of left hip-joint; general condition precarious. Resection of joint with five centimetres of the shaft of femur; the latter was done for suppurative osteomyelitis which affected this portion of the bone. Death fifty-three days after operation from tubercular meningitis, as was confirmed by the autopsy.

Case IV. Girl aged 5 years; coxitis left side and perforation of cotyloid cavity. Resection. Death from basilar meningitis fifty-three days after operation.

Case V. Young man with hereditary history. Injury of knee and forearm; arm amputated about through the middle. Diagnosis of tubercular meningitis made fifty-three days after operation; death two days later. Autopsy: Acute basilar meningitis with acute hydrocephalus, also acute miliary tuberculosis of lung.

Case VI. Man 32 year old, received an injury of the knee which made an amputation of the thigh necessary about one year and three quarters later; tubercular meningitis two days later, and death one day later. Autopsy: Recent basilar meningitis, miliary tuberculosis of lungs and peritoneum, also tubercular ulcer of intestine.

Case VII. Boy 9 years old, with fungous arthritis of knee-joint of three years' duration. Resection. Death thirty-nine days after operation, from tubercular meningitis. Autopsy: Tubercles at base of brain, in the lungs, spleen, liver, and kidneys; no caseous foci.

Case VIII. Child 3 years old; tuberculosis of calcaneus with fistulæ. Scraping out of diseased bone and injection with chloride-of-zinc solution. Death seven months later, preceded by cerebral symptoms and incipient pulmonary phthisis. Autopsy: Bilateral caseous nodules in cerebellum the size of an apple; tuberculosis of lung, mesenteric glands, and intestines.

Case IX. Man aged 23, with a white swelling of knee of several years' duration. Resection of joint. Death six weeks later, from tubercular meningitis.

Case X. Boy 7 years old. Arthritis of knee-joint of several years' duration. Resection. Death sixty-eight days later, from tubercular meningitis.

Case XI. Esmarch lost a little patient from tubercular meningitis sixteen days after resection of a tubercular wrist-joint.

Case XII. Girl 3½ years old, suffering from tubercular coxitis for one year. Resection of head of femur and scraping of acetabulum. Death thirty-nine days afterward, from tubercular meningitis.

Case XIII. Child aged 1½ years, with white swelling of knee for three months. Resection. Death a week after operation, from diarrhœa and convulsions.

Case XIV. Tibio-tarsal arthritis. Resection. Tubercular meningitis six days later, and death the following day. Old and recent pulmonary tuberculosis. ("Socin and Keser," p. 136. Basel, 1884.)

Case XV. Amputation of the leg through upper third for tibio-tarsal arthritis, in a young boy. Healing by first intention during the second week. Death from tubercular meningitis and acute miliary tuberculosis of lung, twenty-seven days after operation.

Case XVI. Child 6 years old. Tibio-tarsal tuberculosis with deep-seated osseous foci. Ignipuncture in ten different places. No indications of pulmonary or meningeal tuberculosis until twelve days after cauterization of the interior of the joint, when a tubercular meningitis set in and proved fatal in thirteen days. Diagnosis confirmed by the autopsy.

Case XVII. Child 6 years old, convalescent from an attack of measles, was kicked on the left fronto-parietal region, causing ecchymosis and swelling, and ten days later headache, vomiting, and fever. In sixteen days death from tubercular meningitis. (Ozenne, *Bull. Médicale*, 1887, p. 524.)

Case XVIII. Boy 7 years old, suffering from otitis media for several months. Mother, brother, and several sisters died of phthisis. Contusion of head, caused by striking against wall, is followed by malaise and headache, lasting ten days, then found unconscious. When admitted to hospital, two days later, the following symptoms: Unconsciousness; pupils equal, react to light; respiration easy, but shallow; small, irregular pulse; lips and tongue coated; abdomen very contracted; ex-

tremities rigid; continued nearly in same condition until death, twelve days later; cerebral convolutions flattened; disseminated tubercles at base of brain, near the fissure of Sylvius, with very marked evidences of meningitis; considerable fluid in ventricles, and dilatation of the foramen of Monro; lungs studded with recent tubercles, especially in the apices; caseous foci in the renal pyramids, with some pyelitis.

In addition to these cases the same authors report three cases in which the cerebral affection made its appearance more remotely from the time of operation, but in which the secondary infection, from the absence of caseous foci in other organs, had to be connected with the primary lesion subjected to operative interference. Thiéry cites a number of cases of tubercular meningitis following operative treatment of tubercular affections:—

Case I. Volkmann. Coxitis on right side. Ignipuncture and *raclage* May 1, 1874. Meningitis and death August, same year. Autopsy reveals tubercular meningitis, and acute tuberculosis of liver, lungs, and spleen.

Case II. Wahl. Chronic abscess behind left trochanteric region. Resection. Sixty-six days after operation, death from tubercular meningitis.

Case III. Wahl. Left coxitis with multiple abscesses. Resection. Fifty-three days after operation, death from tubercular meningitis.

Case IV. Volkmann. Left coxitis and iliac abscess. Resection March 11, 1873. Basilar meningitis April 28th, and death May 3d.

Case V. König. Fungous arthritis of knee. Resection November 18, 1869, and death from tubercular meningitis December 27th.

Case VI. Sayre. White swelling of knee. Resection. Tubercular meningitis, and death six weeks later.

Case VII. Billroth. Chronic inflammation of knee-joint. Resection May 1, 1860. Tubercular meningitis, and death July 7th.

Case VIII. Hinsch. Esmarch's case, previously quoted.

Case IX. Coxo-femoral caries. Resection on thirty-ninth day; death from tubercular meningitis.

Case X. White swelling of knee-joint. Resection. Death eight days later, preceded by diarrhœa and convulsions (child $1\frac{1}{2}$ years old).

Case XI. Fall on head. Death from tubercular meningitis (previously cited).

I could add several cases of tubercular meningitis and diffuse miliary tuberculosis following operative procedures from my own experience, but enough cases have been quoted to show that the danger from this source is real, and not imaginary, and should always be borne in mind in performing operations for tubercular lesions with a view toward preventing traumatic dissemination. It is not difficult to conceive the *modus operandi* of the occurrence of re-infection during and shortly after operations for tubercular affections, more especially if the operation is incomplete. The scraping, resection, or amputation wound opens numerous veins in the bone, the lumina of which remain patent, ready for the introduction of minute fragments of granulation tissue or free bacilli, which, on entering the general circulation, are the direct cause of metastatic tuberculosis in distant organs. We must take it for granted, in such cases, that a tubercular focus, during the operation, furnished the essential cause of the distant lesions,—infected fragments of granulation tissue or free bacilli, which are aspirated or pushed into the openings of the wounded vessels, and through them gain entrance into the general circulation. Statistics prove only too plainly that re-infection is most likely to take place when the operation is imperfectly done, and is, therefore, more frequently incurred by scraping than complete eradication of the primary focus by excision. To guard against such an accident, in operating upon tubercular joints, it is necessary to remove from the joint all possible source of infection before the atypical or typical resection is made. The infected soft structures of the joint

and loosened cartilage should be carefully removed and the surfaces disinfected before the chisel or saw is used; in other words, a typical arthrectomy should precede the resection. Cartilage that remains firmly attached to the bone may be left. After all foci in the articular ends of the bone have been radically eliminated, the field of operation is again flushed with a strong aqueous solution of iodine, and, after drying and iodoformization, the bone-cavities, if such exist, are packed with decalcified, antiseptic bone-chips, when the operation is completed in the same manner as in arthrectomy.

CHAPTER XXIX.

Amputation.

Amputation of a limb on the proximal side of a tubercular joint must be regarded as the most radical treatment of the local lesion, and as affording most efficient protection against reinfection of the body from this source. Although amputation has become more and more restricted as other less mutilating operations are being made safer and more efficient in the treatment of tubercular affections of the extremities, it will always hold a legitimate place in the treatment of grave cases beyond the reach of less heroic measures. Although Benjamin C. Bell ("Diseases of Joints," p. 150. London, 1850) had no conception of the true nature of tubercular disease of joints, his reasoning in favor of complete removal of the peripheral local disease by amputation, in appropriate cases, must be considered as logical and correct at the present day. "It is to be observed that this disease of a joint is very rarely more than the remote cause of death, and that, when the result is fatal, it almost invariably happens in the following manner: The patient is exhausted by hectic fever, and in this state of debility disease takes place in the mesentery or lungs, or, not unfrequently, in both these parts at the same time, and it is this visceral affection which immediately precedes dissolution. It is evident, then, that in many cases there is a period of time at which the amputation of the limb may be the means of preventing the establishment of a secondary disease. Nor is this all; visceral disease, which was previously in a state of inactivity, may assume a new form and begin to make a rapid progress under the depressing influence of the disease of the joint. Amputation under these circumstances may be the means of preserving the patient, if not altogether, at least for a considerable length of time,—perhaps for several years."

Ollier ("Des Operations conservatrices dans la tuberculose

articulaire." Copenhagen International Medical Congress, 1884) has well said that amputation is undoubtedly that operation which furnishes the greatest safety against infection from the local disease in the bones or joints, but it cannot be regarded as a radical operation because deep-seated and inaccessible lymphatic glands are left behind, which in old cases are always more or less affected. Amputation is especially indicated in osteo-arthritis of the lower extremities, as it is important to remove the patient as soon as possible from the debilitating influences of prolonged confinement in bed.

Pilcher ("Notes on Amputation for Joint Disease when Lung Tuberculosis Co-exists." *Annals of Surgery*, vol. v, p. 101) has again called attention to the value of amputation as a surgical resource in the treatment of tubercular joints complicated by pulmonary phthisis. He urges this operation particularly in the case of adults, in which other less heroic measures hold out less encouragement than in children. He maintains that amputation wounds in such cases heal as promptly as when amputation is done for other indications, and that very often patients reduced to a skeleton under the combined influence of several wasting diseases recover flesh and health after the removal of the peripheral lesion by amputation.

Thiéry (*loc. cit.*, pp. 451 and 452) has made a study of ninety-four cases of tuberculosis of the extremities to ascertain the comparative merits of amputation and resection:—

Amputation.		Resection.	
Deaths,	27	Deaths,	36
Complete recovery,	12	Complete recovery,	9
Incomplete recovery,	5	Incomplete recovery,	5
	44		50

In this connection Boeckel's material, consisting of 204 cases, covering a period of fourteen years,—1875 to 1888 inclusive,—is of great value. It embraces 53 amputations and 151 resections; of the latter, 27 resections of large joints and 24 re-

sections of bones of the trunk. Resections of small joints and *les évidements osseux* are not included in this list. Amputations: The 53 cases furnished *en bloc* 49 recoveries and 4 deaths. Fourteen have been lost sight of since leaving the hospital; the others were heard from later. They are described as follows: Thigh, 17 cases, with 1 death six weeks after operation, from a heart affection in the case of a woman 70 years old. Two others died two months after amputation,—one of phlebitis and the other of osteomyelitis; 2 died two and three years after amputation,—one of pneumonia and the other of cerebral hæmorrhage; 12 are alive and in good health,—seven, twelve, and fourteen years; the oldest of these survivors had, at the time the report was made, attained the age of 80 years. Mortality 5.8 per cent.; no deaths from tuberculosis.

Leg and Arm.—Twenty-two cases with 19 recoveries and 3 deaths. One died in five weeks from pulmonary phthisis; another in three weeks, from *hæmoplysie foudroyante*, after amputation of leg; the third died from exhaustion forty-eight hours after amputation of arm. Of the 19 recoveries, 5 were lost sight of after three years; of the remaining 14, only 10 are alive after two, three, five, eight, nine, ten, eleven years, and in good health. The other 4 survived eighteen months, then died of pulmonary phthisis; five years, same cause of death; eight years, marasmus. Lastly, a woman of 64 years, arm amputated, was in good health for six years; then a tubercular osteo-arthritis necessitated amputation of the thigh, which she survived two years, finally dying of albuminuria.

Of the 39 patients who survived the operation for several years, only 22 were alive at the time the report was made. Of this number it is said that 2 or 3 had pulmonary tuberculosis; one had attacks of hæmoptysis for two years, and another was the subject of "cavernules." Resections of joints are classified thus:—

	Cases.	Recovered.	Death.	Mortality.
Shoulder, . . .	6	6	0	0
Elbow, ...	12	11	1	8.3 per cent.
Wrist, ...	2	2	0	0. "
Hip, ...	32	20	12	37.5 "
Knee, ...	58	55	3	5.1 "
Foot, ...	17	17	0	0. "
Total, . . .	127	111	16	12.6 "

A subject of some interest, in connection with amputation for tubercular affections, is the fact that sometimes tubercular ulceration may appear in the stump after amputation, although the previous disease for which the operation was made may not have been tubercular in its nature, or when amputation is made through perfectly healthy tissue for tubercular lesions. Verneuil described this condition some years ago as he observed it in a case which, condensed, is as follows: A boy from the country, 15 years old, in apparently good health, was the subject of an articular and tendinous synovitis, which finally made an amputation necessary. Union of wound by primary intention, except at a point occupied by the inner drainage-tube, where a small ulcer formed. This ulcer was very superficial, but gradually increased in size. In the granulations of this ulcer Nepveu demonstrated the existence of giant-cells and tubercle bacilli. The usual applications proved useless in arresting the destructive process, which was only accomplished by deep cauterization with the actual cautery. Verneuil remarks, in commenting on this case, that two hypotheses might be advanced to explain the causation of the ulcer. Either the tissues at the site of amputation were infected with tubercle bacilli, or the wound was infected during the operation; but he felt sure that the tissues of the amputation wound were perfectly healthy at the time the operation was made, and is inclined to the belief that infection was brought about by the localization of microbes in the wound (auto-infection), or by their introduction from without (traumatic infection). Traumatic infection of an amputation wound, when the operation is performed for the removal of open tubercular lesions, should be prevented by covering the ulcerated surface

during the operation and by careful disinfection of the whole limb. In the treatment of tubercular affections of the extremities amputation must be reserved for cases presenting special indications. It is the only operation that promises any benefit if the patient suffer at the same time from tuberculosis of other organs, provided the general conditions furnish no positive contra-indications. It is also indicated if a tubercular abscess has perforated the capsule of a joint and has extensively infiltrated the surrounding tissues. This condition is to be expected if the limb has become œdematous some distance from the joint. Pronounced anæmia should influence surgeons to lean toward amputation rather than resection in tuberculosis of the large joints. It is absolutely necessary to use healthy tissue for the flaps. Œdematous skin, or skin riddled with fistulous tracts, must be carefully avoided. The flaps must be taken from the side of the limb where the skin is in the best condition, and the incision through the deeper parts must fall through healthy tissue. Esmarch's bandage should never be employed in operating for tubercular affections, as its use might bring about infection of previously healthy tissues. The limb should be rendered bloodless by elevation of limb and elastic constriction some distance above the site of operation. It is astonishing how rapidly wounds heal and how quickly patients will recover after amputations for extensive local tubercular processes, even when greatly emaciated by the disease.

CHAPTER XXX.

Post-Operative Treatment.

As the eradication of a local lesion by operative measures seldom, if ever, succeeds in eliminating from the organism all sources of infection, the local should always be combined with general treatment. As the general treatment has been discussed elsewhere, it is necessary here only to refer again to the importance of carrying it out faithfully and persistently after all operations for tubercular affections, in order to so improve the general health that remaining sources of infection may become harmless after the removal of the principal peripheral focus from which re-infection did or might take place. The knife, saw, sharp spoon, and Paquelin cautery must be preceded and followed by efficient, well-conducted general treatment. The surgeon must be a physician as well as a surgeon in the successful treatment of such cases. The use of guaiacol, as advised by Schueller, should be continued for three months to a year after operation, in doses of 2 to 5 drops three or four times a day, according to the age of the patient. If more attention were given to appropriate after-treatment than has usually been the case in the hands of most surgeons, statistics of operative results, both immediate and remote, would present a less gloomy aspect. Improvement of the general health of tubercular patients by general treatment is but calculated to secure a satisfactory process of repair after operative interference, and affords the most efficient protection against local recurrence and general dissemination. In order to secure the best results it is necessary for the surgeon to prepare patients properly for the unavoidable operative treatment, which may require weeks or months, and to conduct the necessary after-treatment not only until the wound has healed, but until the patient has regained his usual health. Sunlight, out-door air, and a nutritious diet are the best tonics in the building up of tubercular patients. A change of climate is

often productive of marked improvement in patients that have recovered from the immediate effects of an operation. Dressings should be changed as infrequently as possible, as each change is attended by some risk of infection as long as the external wound is not healed completely. Physical and psychical rest is an essential condition in procuring a satisfactory wound-healing after operations for tubercular affections. Physical rest is secured by proper mechanical support of the part or limb operated on, by position and fixation dressings, while psychical rest is obtained by the avoidance of unnecessary pain, and by careful attention to the surroundings of the patient. Local relapse must be suspected if the wound show no tendency to heal and become covered in a few days by profuse, soft, almost gelatinous granulations, or if the wound has healed by the characteristic appearance of the cicatrix. The cicatrix, instead of undergoing atrophy and becoming paler from day to day, presents a swollen, œdematous, and livid appearance. In a short time the epidermis is destroyed, the whole cicatrix melts away, and its place is taken by pale, fungous granulations, which manifest no reparative tendencies. A local relapse calls for prompt operative interference. The granulations should be removed thoroughly with a sharp spoon,—a procedure which often makes it necessary to reopen the operation wound in order to reach all of the infected tissues. Such an operation requires all the antiseptic precautions as the first operation, because tubercular wounds are exceedingly susceptible to infection with pus-microbes. The scraping is to be continued until firm, healthy tissue is reached. The wound is now irrigated with strong iodine-water, dried, iodoformized, and, if large, partially sutured. An iodoform-gauze tampon should be used and allowed to remain for at least five days. The part is dressed in the same manner as after the first operation. Sometimes the operation wound heals in a satisfactory manner with the exception of one or more fistulous tracts. These should be scraped out thoroughly under strict antiseptic precautions, and the operation repeated

in four to six weeks if the wound show no tendency to heal. By following such a course of treatment a resection or amputation may finally be made to heal permanently. Amputation after an unsuccessful arthrectomy or resection may become necessary if the local recurrence is extensive and does not yield to a thorough use of the sharp spoon, or if the resection wound becomes the seat of a suppurative inflammation, which proves refractory to free drainage and antiseptic irrigations. A diffuse suppurative inflammation following resection or amputation is best treated by constant irrigation with a saturated solution of acetate of aluminum, free drainage, and covering the parts with a thick hygroscopic compress saturated with the same solution.

CHAPTER XXXI.

Tuberculosis of Special Bones.

Tuberculosis of the Bones of the Head.—Although tubercular inflammation presents a great resemblance in the different organs and tissues of the body, it is greatly modified by anatomical location and structure of the tissues affected, which influence the clinical course, affect the prognosis, and often require special methods of treatment. The therapeutic measures which are now being employed in the treatment of tubercular affections of different bones and joints, as well as the number of operative procedures for their radical treatment, have become so numerous that in a general treatise on tuberculosis of bones and joints it would be difficult, if not impossible, to enumerate and apply them with sufficient clearness and precision to enable the practitioner to make an intelligent selection for special indications. It is only too often the case that a method of treatment, perhaps of great value in the treatment of special forms of bone or joint tuberculosis, has fallen into disrepute because it was indiscriminately applied in the treatment of all forms of tuberculosis. In the successful treatment of tubercular affections it is of the greatest importance to avoid routine work and meet special indications according to age and general condition of patient, location and extent of disease, and the presence or absence of complications. To make this book more valuable as a work for reference, and as a guide to the busy practitioner, I have deemed it advisable to add a few chapters on the diagnosis, pathology, prognosis, and surgical treatment of tuberculosis of special bones and joints.

Bones of Skull.—Chronic inflammatory affections of the bones of the skull were formerly regarded as one of the manifold manifestations of a strumous diathesis. Benjamin Brodie ("A Treatise on the Diseases of the Bones," p. 26. London, 1828), in speaking of scrofulous inflammation of bone, alludes to the disease as affecting the cranium as follows: "When scrofulous

inflammation attacks the bones of the cranium it is in general preceded by inflammation of the cellular tissue and periosteum covering them. A defined swelling, unattended by pain or pressure, is first felt; it is soft and elastic, and, in the course of a few weeks, if left to itself, an opening takes place, through which is discharged a sero-purulent matter, which has sometimes, though not always, a fetid smell. On introducing a probe into the opening the bone is found to be bare, and sometimes rough on its surface. After some time minute scales of the external lamina of the bone occasionally separate and are discharged. If the disease stop here granulations arise from the diploë, and an osseous cicatrix is gradually formed; but in individuals of a highly scrofulous diathesis, *the disease penetrates completely through the bone.* [Italics my own.] Even after this untoward event has taken place, and when the general health has been improved by the exhibition of appropriate remedies, a cure is, as I have sometimes seen, effected by means of the adhesive inflammation, and the solution of continuity is closed up by a deposition of a fibro-cartilaginous matter."

In reference to the cause of necrosis, the same author remarks further: "That the destruction of the bone is not occasioned by the pressure of matter, but by what Van Helmont has termed *corruptor*, and John Hunter *morbid action*, in the vessels of the bone itself, is proved by the fact that a similar result ensues when an early opening has been made and the matter allowed to escape." This classical description of the macroscopical pathological changes which occur in the cranial bones when the seat of tuberculosis is so accurate that it serves a useful purpose to-day in giving a description of the disease with a view of its recognition at the bedside.

Cranial Vault.—At the present time tuberculosis of the cranial bones is a well-recognized lesion, and, although not of very frequent occurrence as compared with similar affections of other bones, the clinical observations made are sufficient to

impart to this subject a special interest at this time. The flat bones are affected in children and adults. The frontal bone is the most frequent seat, especially at a point in the neighborhood of the orbital margin and external angular process. Occasionally the parietal and more rarely the occipital are also

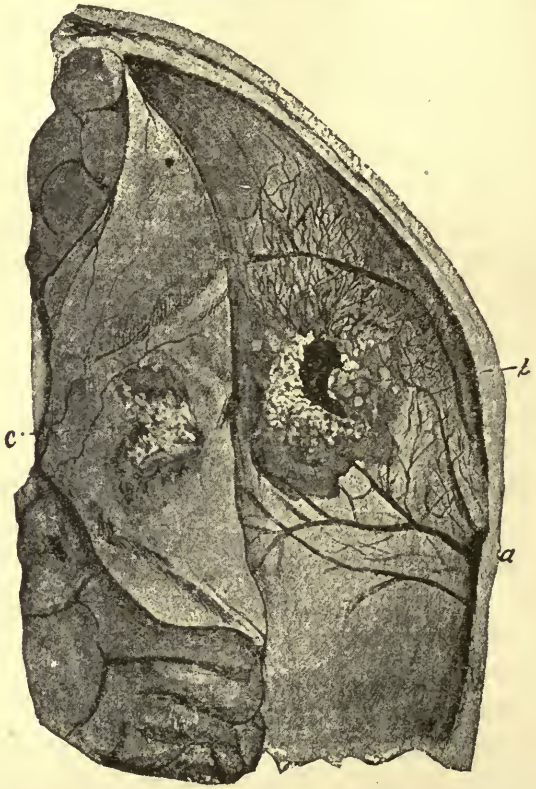

FIG. 40.—TUBERCULOSIS OF CRANIAL BONES. INNER SURFACE OF CRANIAL VAULT AFTER SEPARATION OF DURA MATER AND BRAIN, WHICH ARE PUSHED TOWARD THE LEFT. (*Krause.*)

a, middle meningeal artery; *b*, perforating irregular defect in parietal bone around the opening tubercular eruptions and caseous infiltration of bone; *c*, tubercular circumscribed pachymeningitis.

primarily affected. Local extension of the disease is one of the characteristic clinical features. The diploë is more frequently the primary starting-point than the periosteum. In the former locality it is met with either as a caseous focus or tubercular necrosis. The sequestra are generally small,—seldom larger

than a split pea. In Volkmann's cases the internal table was more extensively destroyed than the external.

The cranial affection is very often complicated by tuberculosis in other organs. Volkmann ("Die perforirende Tuberculose der Knochen des Schädeldaches." *Centralblatt f. Chirurgie*, No. 1, 1880) gave the first most thorough pathological and clinical description of this disease. His paper was based on twelve cases that came under his own personal observation, and in all of them the disease was located in the frontal or parietal bone. In every case the disease was circumscribed, but involved the whole thickness of the bone, so that the caseous sequestrum came externally in contact with the periosteum and internally with the dura mater. (Fig. 40, *c*). Almost in all cases a chronic abscess with relaxed walls formed under the scalp which contained genuine tubercular pus, and its walls were lined with fungous granulations in which tubercles could be detected. In six of the cases the sequestrum had not become detached, and was removed with the chisel; in the remaining cases it was scooped out with the granulations with the sharp spoon.

Gangolphe ("Tuberculose perforante du crane." *Lyon Médicale*, No. 46, 1887) gives an excellent description of the pathological conditions of one case of tuberculosis of the skull which he examined. The patient was a child 4½ years old, which died after resection of the hip-joint. The immediate cause of death was basilar meningitis. Among the multiple tubercular lesions he found a tubercular focus in the skull, which, as is usually the case, appeared in the form of a perforating caseous sequestrum without any evidences of inflammation in the adjacent bone and periosteum. Gangolphe makes the statement that the bone is the primary seat of this disease, and calls attention to the difference between it and syphilis of the skull, in which the bone appears worm-eaten, traversed by fine spiral channels, while the tissues around are swollen, indurated, and covered by numerous periosteal deposits of new bone. *The*

absence of pain and tenderness and the absence of new bone within or in the immediate vicinity of the inflammatory product in tubercular affections of the cranial bones always distinguish this affection from syphilitic lesions in the same locality. Another very instructive case of tuberculosis of the cranial vault is reported by Israel ("Fall von tuberculöser ostitis des Schädels." *Berl. klin. Wochenschrift*, No. 10, 1886). A boy received a slight injury in the temporal region, from which he recovered in eight days. Three months later he returned to the hospital with a fistula at the seat of former injury. The probe could be inserted deeply between the skull and cranium. Gradually three swellings, each the size of a quarter of a dollar, appeared in the same locality. The swellings were somewhat tender on pressure, and fluctuated distinctly. Fever set in, which was followed by serious brain symptoms, vomiting, somnolence, and strabismus. The skull was exposed, and a caseous sequestrum was removed. The dura corresponding with one of the foci was covered with fungous granulations. Subsequently similar swellings appeared in the direction of the external ear. These were incised and scraped out, whereupon the cerebral symptoms disappeared. Later, the right ankle-joint and all the metatarsal joints on same side became the seat of tuberculosis. Amputation finally became necessary, after which the patient recovered. In this case the cranial disease followed an injury to the skull, and, as the boy was in good health, and as there was no previous tubercular disease elsewhere, it was in all probability caused by infection through the wound. That the extension of the disease in the direction of the brain sometimes reaches this organ is illustrated by a case reported by Hauser ("Ueber einen Fall von perforirender Tuberculose der platten Schädel-Knochen," etc. *Deutsches Archiv f. klin. Medicin*, B. xx, Heft 3 u. 4, p. 267). The patient was a woman 51 years old. In April, 1886, she was taken with pain in the hip; at the same time a cough appeared, attended by purulent expectoration. In June she sought hospital treatment. At this time a swelling had formed, the

size of a pigeon's egg, over the orbital margin of the frontal bone, which was only slightly painful and fluctuated distinctly. Under the swelling the bone presented a depression, while around it was more prominent. A second, smaller swelling was found over the base of the nose on the same side. As no bacilli could be found in the expectoration, the cranial affection was considered as syphilitic in its nature. Large doses of potassic iodide produced no effect. In June the abscess was incised and a colorless fluid escaped, in which tubercle bacilli were found. The patient died the following month. The necropsy revealed, besides other tubercular affections, several osseous foci in the cranial vault, and at one point the tubercular process had extended beyond the meninges into the gray substance of the brain.

Removal of the tubercular product should be undertaken before sequestration has taken place, as this process often requires a long time, and as during this time local extension and general dissemination are prone to take place.

Kümmell ("Zur Trepanation bei Tuberculose der Schädel-Knochen." *Deutsche Med. Wochenschrift*, B xiii, p. 605). The portion of bone to be removed can be outlined accurately by the characteristic yellowish-white appearance of its external surface. As the internal table is usually more extensively involved than the external, it is often necessary to chip away with the chisel as much as a quarter of an inch of the surrounding healthy bone before the circular sequestrum can be lifted out. As with few exceptions the entire thickness of the bone is involved, the circular craniectomy should be made complete. Granulations between sequestrum and dura are to be removed with the sharp spoon. After thorough disinfection the defect in the bone should be filled with a decalcified antiseptic bone-disc, which should fit the opening accurately, and the external wound sutured except at the lowest angle, which is left open for a tubular or capillary drain.

Temporal Bone.—The temporal bone is very frequently

the seat of tuberculosis. The favorite localities are the internal ear and the mastoid cells. That an ordinary otitis media with perforation of the tympanum may occasionally be transformed into a tubercular lesion, by the entrance of tubercle bacilli from without, there can be no doubt. Habermann ("Mittheilung über Tuberculose des Gehörorgans." *Prager Med. Wochenschrift*, No. 6, 1885; also "Ueber die tuberculöse Infection des Mittelohres." *Prager Zeitschrift für Heilkunde*, Band vi) several years ago investigated this subject by examining, post-mortem, eighteen tubercular subjects, in whom otorrhœa or deafness without active discharge had been observed during life, and in nine of these he could demonstrate the presence of tubercular lesions in the auditory canal. In one case he found, in the left auditory apparatus, tuberculosis of the entire middle ear where the tympanum was intact. In another tubercular subject, a man 38 years of age, in whom tuberculosis of the ear was observed a year and a half before death, the autopsy revealed extensive tuberculosis of the cochlea, in the internal auditory canal, and in the superior semicircular canal, while the other semicircular canals and the vestibule were destroyed by caries. Infection with the bacillus tuberculosis of granulations in the middle ear through a perforation in the tympanum can occur in persons otherwise in perfect health. The diagnosis in such cases can be readily made by removing fragments of granulation tissue for microscopic examination. If they are found to contain tubercle bacilli a positive diagnosis has been made, and no time should be lost in resorting to a radical operation.

Habermann regards caries of the petrous portion of the temporal bone in most instances as a tubercular process, caused by tubercular disease of the mucous membrane lining the internal ear. In order to prove the correctness of this assertion he did not rely on his clinical observations, but made careful post-mortem examinations of these parts after death, in patients who had died of tuberculosis. One of the cases he examined concerned a woman 32 years of age, who had died of general

tuberculosis. The membrana tympani on the left side was found intact; nevertheless, he found, in the middle ear and the mastoid cells, a mass of cheesy material which contained numerous tubercle bacilli. The mucous membrane of the middle ear showed the characteristic appearances of diffuse tuberculosis, and from here the disease had extended to the bone. The same conditions existed in the drum of the ear, the process extending from within outward. He believes that infection occurred by the entrance of tubercle bacilli through the Eustachian tube during violent attacks of coughing. In all of the cases which he examined it was evident that the process commenced on the surface of the mucous membrane, and extended from here in the direction of the bone. In three cases the surface of the bone showed evidences of lacunar absorption, while in two cases it was extensively diseased.

Nathan ("Ueber das Vorkommen der Tuberkel bacillen bei Otorrhœen." *Deutsches Archiv f. klin. Medicin*, B. xxxv) examined the pus microscopically in forty cases of otorrhœa and found in twelve of them tubercle bacilli. In eight of the patients tuberculosis in other organs was present. In three cases, in which bacilli were found in the pus, no pulmonary tuberculosis; but in all of these the disease had extended to the bone, and in two of them caries of the bones of the internal ear was present. Voltolini ("Ueber Tuberkel bacillen im Ohre." *Deutsche Med. Wochenschrift*, No. 31, 1884) reports two cases of suppurative otitis in which he found tubercle bacilli in the pus. In one of them the patient suffered at the same time from pulmonary and laryngeal tuberculosis; in the second no evidences of the disease in any other organ could be found, but death occurred from marasmus in six months. In the last case extensive destruction of the bony parts of the organ of hearing and the surrounding bone was present. As the Eustachian tubes were intact, the author believes that infection occurred through the circulating blood. Ritzefeld ("Ueber die Tuberculose des Ohres." Dissertation. Bonn, 1884) made a

bacteriological examination of the inflammatory product escaping from the middle ear in four patients suffering at the same time from pulmonary tuberculosis, and found tubercle bacilli in all of them.

A most excellent description of the pathological conditions found in tuberculosis of the auditory apparatus and the temporal bone in the pig is given by Schütz ("Die Tuberculose des mittleren u. inneren Ohres beim Schweine," etc. Virchow's *Archiv*, B. lx, p. 93). According to this author, the tubercular process extends from the pharynx along the Eustachian tube to the middle ear, and from here to the surrounding bone, and, after perforation of the membrana tympani, to the external ear. The process often extends to the dura mater and the mastoid cells. In the mastoid process the disease provokes a tubercular periostitis. The bones of the internal ear are often destroyed. Participation of arachnoid, medulla oblongata, and brain frequently takes place. Lymphatic infection and tuberculosis of other organs constitute frequent complications.

Tuberculosis of the internal ear and mastoid cells requires early and radical treatment in all cases in which the absence of serious complications warrants such treatment. The surgical treatment must be conducted upon the same principles as when the disease is located in other accessible organs. The removal of the infected granulations with a sharp spoon, followed by irrigation with iodine-water or 3-per-cent. solution of boric acid, and iodoformization of the cavity are the measures to be employed in removing the infected focus and in preventing extension of the disease into other parts of the ear, the mastoid cells, the meninges, or the brain itself. The complete removal of all of the infected tissues will often render it necessary to sacrifice the auditory apparatus, but this is not to be taken into consideration when the surgeon is called upon to remove a tubercular focus in a locality in which it can at any time become the source of a fatal complication. The operation must be made under strict antiseptic precautions, and the tubular

wound must be protected against subsequent infection by appropriate dressing. Tubercular mastoiditis must be treated in a similar manner as suppurative inflammation in this part of the temporal bone,—removal of the external compact layer with the chisel, and removal of the tubercular product with the sharp spoon. It is necessary, in such cases, to fully expose the tubercular focus with the chisel, and, after scraping out the cheesy material and thorough disinfection, the cavity should be filled with antiseptic decalcified bone-chips, over which the periosteum and overlying soft parts are sutured separately.

Sphenoid Bone.—Lüthemüller ("Keilbeincaries mit Amaurose." *Wiener Med. Blätter*, Nos. 1, 2, 3, 1880) describes a case of tubercular caries of the sphenoid bone in the person of a man 20 years of age, who suffered for months from intense headache, otitis purulenta media of right ear, and complete amaurosis. Death was preceded by well-marked symptoms of basilar meningitis. The autopsy revealed at a point where the optic nerves cross each other, together with the trigonum olfactorius on both sides and the tuber cinereum imbedded in a yellowish-gray mass, surrounded by a vascular layer which contained numerous miliary nodules; in this mass the tractus opticus was lost. Beneath, the mass was connected with tubercular material, interposed between it and the sella turcica of the sphenoid. A considerable portion of the bone was denuded of its covering, and the disease involved the bone itself.

According to the author, tubercular disease in this locality can be suspected in chronic ozæna, followed by blindness and basilar meningitis. According to Borel-Laurer ("Sur la Symptomatologie des caries osseuses dans la profondeur de la face." *Cor. f. S. Aerzte*, No. 3, 1880), caries of the ethmoid and sphenoid is not so rare. Cases present, besides a visual disturbance, psychical alteration, especially melancholy. In two cases removal of the disease by operation restored health.

Bones of Face.—Tubercular affection of the facial bones is met with almost exclusively in children, although I have seen

two cases in men over 20 years of age. The orbital margin of the malar bone is most frequently the seat of disease; next in frequency comes the lower maxillary bone. The upper maxilla is usually affected secondarily, the disease extending to it from the periosteum or the other soft tissue surrounding it. Tuberculosis of the malar bone is attended by local conditions which are pathognomonic of this affection. At a point usually near the centre of the orbital margin a circumscribed swelling forms in the soft parts which is almost painless and slowly softens, the skin becomes livid and attenuated, when, either by incision or spontaneous rupture, a small quantity of tubercular pus is evacuated. The probe leads to denuded bone. Later, sequestra, usually small in size, are exfoliated and escape or are removed, after which the opening closes permanently, leaving an adherent scar. Ectropium of the lower eyelid is often the remote consequence of tuberculosis of the malar bone.

Nasal Bones.—Tuberculosis of the nasal bones occurs either as a primary osseous affection—tubercular osteomyelitis—or by extension of tuberculosis of the mucous membrane to the subjacent bone. In the former case the disease terminates in sequestration, and recovery is only possible after the spontaneous elimination or operative removal of the tubercular sequestrum. Very often this disease is mistaken for ozæna and treated as such. The affection is frequently quite extensive, and the diseased bone can only be reached and removed by detaching one side of the nose by an incision carried from the ala along the base of the nose as far as the eye. In a case of this kind that I saw in Prof. von Esmarch's clinic, the disease involved both sides of the nose, and in the operation that was performed the whole nose, as far as its root, was detached and reflected. This afforded ample room and free access to the diseased bones.

Riedel ("Die Tuberkulose der Nasenscheidewand." *Deutsche Zeitschrift f. Chirurgie*, B. x, p. 56) has described a tubercular affection of the mucous membrane lining the cartilaginous sep-

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tum of the nose, which, by extension to the nasal bones, gives rise to an osseous tuberculosis resulting in caries. In cases of this kind the vigorous use of the spoon and iodoformization of the wound will often suffice in effecting a permanent cure.

Inferior Maxilla. An interesting case of extensive tuberculosis of the lower jaw, resulting in pathological fracture, is reported by Tachard ("Fracture pathologique du maxillaire inferieur tuberculòse sénile; mort." *Études sur la Tuberculose*, T. xi, pp. 583–588, 1890). The patient was an old soldier in the Infirmary of the Hôtel des Invalides. He was admitted in August, 1887. He had been in active military service for more than thirty years, and had never been sick. Toward the latter part of 1886 his strength diminished without appreciable cause. He emaciated and was forced to enter the civil hospital at Belfort, where he received tonic treatment. When he entered the Infirmary his general health was much impaired; he was languid, pale, emaciated. Teeth in good condition. Never had syphilis. Coughs little, and never expectorated blood. Auscultation revealed nothing abnormal in the lungs. Urinary and other organs presented nothing abnormal. In view of the vague symptoms a positive diagnosis was impossible, and the patient was placed on tonic treatment. August 28th, about two weeks after admission, a fluctuating swelling as large as an orange developed on the right thigh, above the head of the peroneus.

Two aspirations and injections of iodoform cured the abscess. The general health of the patient remained about the same until the spring of 1889, when a periostitis of the inferior maxilla made its appearance at the site of the first left molar, which was extracted many years before. A large incision was made along the lower border of the jaw, externally. During the month of May the gums were deeply ulcerated and two small sequestra were removed through the mouth. The cavity in the bone was thoroughly disinfected and through drainage established. On July 10th the jaw fractured while the patient was

eating his breakfast; the fracture took place through the body of the bone, at a point where the sequestra had been removed. This accident seriously aggravated the patient's condition. Albumen appeared in the urine, the feet became swollen, and death resulted July 30th. Heart fatty; lungs healthy; bronchial glands cheesy; liver and kidneys fatty. At the seat of fracture the inferior maxillary bone contained a typical tubercular focus; loss of bone-substance about two centimetres in diameter. Submaxillary glands caseous. At the costo-vertebral articulations of the first and second ribs on right side, a suppurating osteo-arthritis. In the same articulation of the fifth, eighth, and ninth ribs are also small tubercular abscesses, the largest the size of a hazel-nut. Another tubercular abscess was found behind the sternum, in communication with the fourth and fifth chondro-sternal articulations. While it is seldom that the lower jaw is the seat of such extensive destructive changes resulting from central tubercular osteomyelitis, the periosteal form is much more frequent. This passes through about the same changes and in about the same time as tuberculosis of the malar bone. The disease attacks the outer surface of the bone and the lower border in preference, and, after spontaneous healing or a cure after operation has taken place, leaves a disfiguring adherent scar, which often calls for a secondary operation to correct the deformity. I have repeatedly met with this affection of the lower jaw in patients beyond the age of puberty.

CHAPTER XXXII.

Tuberculosis of the Bones of the Trunk.

Tubercular Spondylitis.—The bones composing the spinal column are more frequently the seat of tuberculosis than all the remaining bones of the trunk. Tuberculosis of the vertebræ is called *tubercular spondylitis*, and, as Percival Pott gave the first accurate description of this disease, it is also called *Pott's disease.* In children tubercular spondylitis is the most frequent form of bone disease. The middle and lower dorsal vertebræ are most frequently affected, then follow the upper lumbar, and lastly the cervical,—of the latter, especially the upper.

Causes.—For a long time it has been maintained, by a few surgeons only, that the local affection produced the general ill health of patients suffering from disease of the spine, and among those who entertained this view belonged Mr. Pott. Mr. Pott (Pott's works edited by Earle, vol. iii, p. 461, edition 1790) was the first surgeon who indicated the real nature of caries of the spine. He expressed himself as follows concerning its causation: "The primary and sole cause of all this mischief is a distempered state of the parts composing or in immediate connection with the spine, tending to and most frequently ending in a caries of the body or bodies of one or more of the vertebræ; from this proceed all the ills, whether general or local, apparent or concealed; this causes the ill health of the patient, and, in time, the curvature, etc." Then originated the idea that an inflamed spine is always the result of an injury. This explanation of the cause of this disease is upheld by many prominent surgeons even at the present time.

Taylor ("Die Orthopædische Behandlung der Pott's chen Kyphose." Berlin, 1873) relates that from 1863 to 1873 eight hundred and forty-five cases of Pott's disease of the spine came under his own observation. In 53 per cent. of these cases he was able to trace the disease to a trauma, fall, blow, or contu-

sion. In 15½ per cent. pulmonary phthisis was traced in near and distant relatives. In 19 per cent. a scrofulous diathesis was apparent; consequently, taking the tubercular and scrofulous cases together, gives 34 per cent. of all the cases, while in 66 per cent. the disease occurred in otherwise healthy persons, not affected by an hereditary taint. In 14 per cent. the disease led to the formation of abscesses. He regards tubercular disease of the vertebræ as an exceedingly rare affection. A vast clinical material carefully observed by many competent surgeons, the co-existence of tubercular affections in other organs, the bacteriological examination of the contents of abscesses starting from the diseased vertebræ, and of the granulations lining such abscesses, as well as numerous post-mortem examinations, have established the fact *that, with few exceptions, all cases of chronic spondylitis are of tubercular origin and nature.* The etiological relation of trauma to tubercular spondylitis is the same as to tubercular affections in other bones. The presence of tubercle bacilli in another organ or the circulating blood is the essential cause, and trauma can be regarded at best only in the light of an *exciting cause.* Most every child in ordinary health falls hundreds of times before it reaches the age of puberty, and yet tubercular spondylitis only occurs in a comparatively small percentage. It is true that the actual development of the disease frequently follows soon after an injury, but in many of these cases there can be but little doubt that the tubercular focus was present at the time, and that *the trauma only aggravated the local conditions.* If the injury bear a more direct causative relation to the development of the disease, we must take it for granted that the tissue-lesions caused by it serve the purpose of a *locus minoris resistentiæ*, in which the tubercle bacilli become arrested and find a favorable soil for their growth and reproduction. The spinal column is so well protected that slight injuries produce no palpable tissue-lesions, and even if they were severe enough to produce contusion or infraction of the bodies of the vertebræ a *tubercular spondylitis could not be*

produced unless the injured person furnished the essential cause, —the bacilli of tuberculosis.

Tubercular spondylitis attacks most frequently children less than 5 years of age, but I have repeatedly observed instances where it developed in persons after the age of puberty. In a paper on "Pott's Disease in Middle and Advanced Life," read by Mr. Marsh at the Second Congress of American Physicians and Surgeons, he expressed himself as being in accord with the teachings of Sir James Paget, that tubercular affections of bones are by no means rare in the aged. He referred to a specimen, in the College of Physicians and Surgeons, of the cervical vertebræ removed from the body of Dr. Buckland, Dean of Westminster. The osseous structure of the lateral masses and adjacent parts of the atlas and axis is deeply eroded and excavated, and the two bones are displaced in relation to one another. Thus the appearances exactly accord with those that are found in caries of the spine in childhood. The patient at the time of death was 72 years of age. The spinal disease was not detected during life.

Drachmann ("Om Spondylitis." *Nord. Med. Arkiv.*, B. vii, No. 17) has collected one hundred and sixty-one cases of spondylitis, and finds the following distribution in reference to age:—

1– 5 years,	66,—41	per cent.
5–10 "	58,—36	" "
10–15 "	22,—13.7	" "
15–20 "	8,— 5	" "
20–25 "	7,— 4.3	" "

From these figures it is apparent that spondylitis is a disease of childhood, as in 74.5 per cent. of all the cases the patients were under 10 years of age.

In regard to location, these same cases yield the following results:—

One or more of the five lower vertebræ,	7.
" " " " " four upper dorsal vertebræ,	20.
" " " " " four middle dorsal vertebræ,	38.
" " " " " four lower dorsal vertebræ,	45.
The lower dorsal vertebræ and upper lumbar,	23.
Lumbar vertebræ alone,	28.

Dorsal vertebræ most frequently the seat, 103 of all cases, or 64 per cent.

Chrystte ("Illustrations of Pott's Disease of the Spine in the Cervical Region," etc. *Medical Record*, Sept. 15, 1873) ascertained that, of two hundred and eighty cases of Pott's disease, treated in the Orthopædic Dispensary, from April, 1869, to February, 1873, in sixty-two, or 22 per cent., the disease was located in the cervical region.

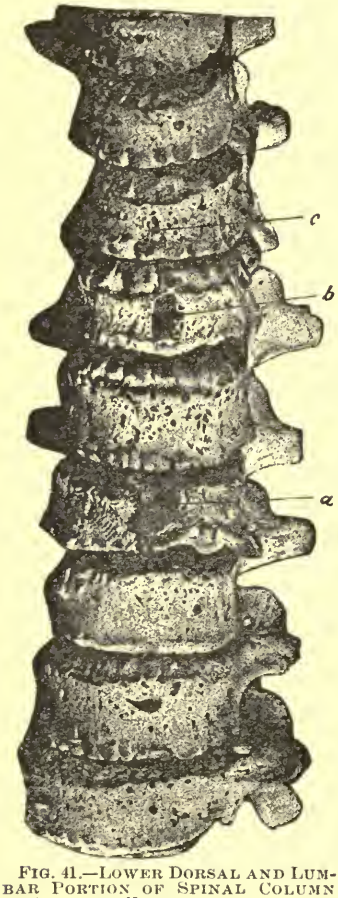

FIG. 41.—LOWER DORSAL AND LUMBAR PORTION OF SPINAL COLUMN OF CHILD. (*Krause.*)

Beginning tubercular spondylitis; death from general tuberculosis; letters indicate location of foci.

Pathology and Morbid Anatomy.—As in bone tuberculosis in other localities, the bone suffers either primarily or secondarily, by extension from the periosteum. The primary osseous is much more frequent than the periosteal form. The primary osseous lesion appears either as a cheesy focus or it is attended almost from the beginning by necrosis. In the vertebræ the tubercular process is characterized by the multiplicity of the primary foci. A number of foci may be present in one vertebral body, or they are scattered over a number of adjoining vertebræ.

In some specimens twenty to thirty, and even as many as one hundred, distinct foci can be demonstrated. In rare cases the disease appears as a diffuse tubercular osteomyelitis. The primary osseous foci usually occur in close proximity to the intervertebral cartilage, and seldom affect more than two vertebræ at the same time. The direction in which the disease extends is usually toward the anterior surface of the vertebræ, and after the disease has extended to the periosteum, the ex-

ternal surface of the bone often becomes extensively eroded. Secondarily the disease travels often over a number of adjoining vertebræ, the tubercular product separating the surfaces of the vertebræ from the periosteum and the ligamentum longitudinale anterius. Occasionally, spurs of bone form in the ligament and connect the vertebræ by bony bridges, immobilizing the parts completely.

When a number of foci become confluent the bone defect becomes extensive, and it is in this manner that often nearly the entire body of one or more vertebræ is destroyed and a sharp posterior curvature is produced.

Feurer ("Anatomische Untersuchungen über Spondylitis." *Archiv f. path. Anatomie*, B. lxxxii, p. 89), in a valuable article on the histological changes in the bone in spondylitis, has shown that lacunar destruction is accomplished by the medullary tissue, in the majority of cases, by the production of giant-cells, but also without these. Besides lacunar destruction, he also describes a vascular destruction of the lamellæ. Vertical to the lamellæ, channels form twice the size of ordinary capillary vessels found in the medulla, which permeate the lamella completely, or terminate blindly in their middle, or unite with each other in their interior in the form of loops. The bone-corpuscles were never seen to take a part in their formation. These channels always contain vessels. The number of channels is variable, and never dependent on the number of medullary vessels. They bear no etiological relation to the lacunar absorption. Of the greatest importance are the changes observed in the myeloid tissue. They are initiated with the diminution of the medullary fat, which always commences first in the centre of the medullary spaces. The next change observed is an increase of lymphoid cells, especially around the dilated blood-vessels; next, proliferation of the connective tissue takes place, after which formation of tubercles follows. In nine out of twelve specimens of spondylitis tubercles were found, and in five out of these nine they were complicated by tuberculosis in

other organs. The superficial form is more frequent in adults than children, and is more frequently associated with the formation of diffuse tubercular abscesses, and if the bodies of the

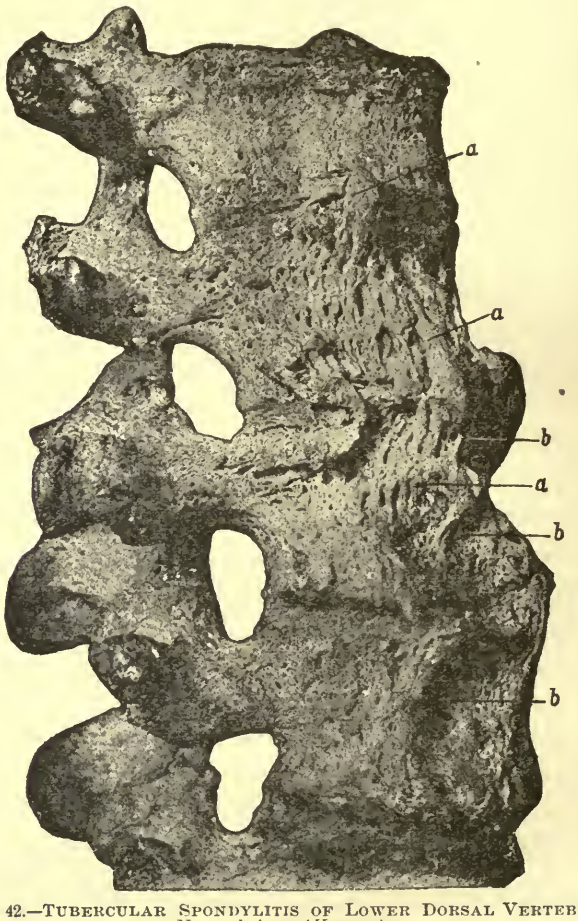

FIG. 42.—TUBERCULAR SPONDYLITIS OF LOWER DORSAL VERTEBRÆ. Natural size. (*Krause.*)

a a, very extensive production of new bone in the anterior longitudinal ligament, that has supported the spine and has prevented the formation of a gibbus; *b b*, small defects upon the anterior surface of the vertebræ.

vertebræ are not much affected no curvature is produced. The deep-seated osseous form is more common in children, and gives rise at an early stage to posterior curvature of the spine. The transverse and spinous processes are rarely affected primarily,

and if this is the case it is usually caused by extension of the disease from the periosteum or ligamentous structures.

There is every reason to believe that tubercular osteomyelitis not infrequently leads to extensive changes of the meninges

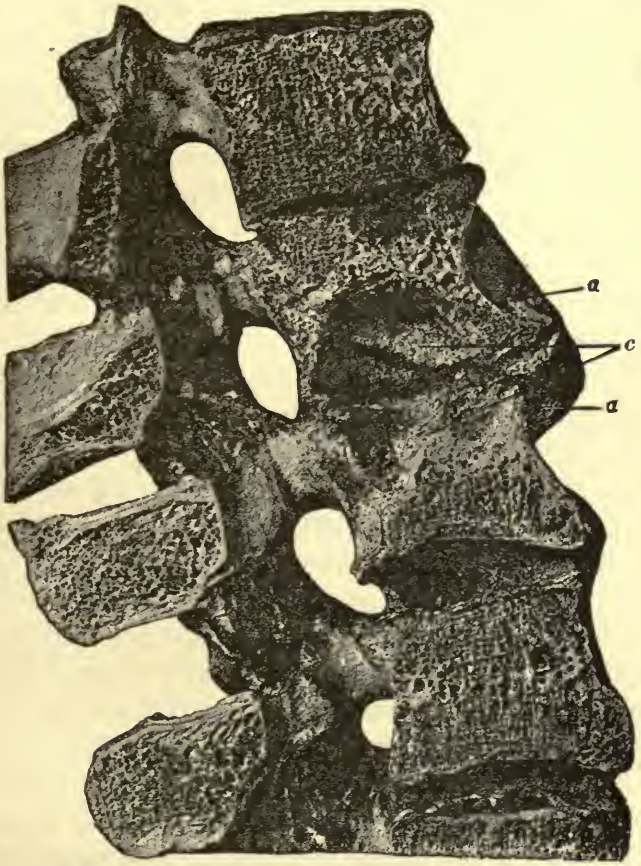

FIG. 43.—SAME SPECIMEN, VERTICAL SECTION. (*Krause.*)

a a, extensive production of new bone in the anterior longitudinal ligament; *c*, large tubercular cavity in the interior of the bodies of two adjoining vertebræ.

of the cord and brain, and of the substance of the cord and brain itself.

Bampfield ("An Essay on Curvature and Diseases of the Spine," etc., p. 43. London, 1824) was very well aware of this fact, as may be seen from the following quotation: "I have

been induced to believe, too, that inflammation and curvature of the spine predispose to inflammation of the brain, for in the year 1822 three patients who had been under my care for diseases of the spine were attacked with phrenitis and died,—the first, a boy, after having been cured of spinal inflammation; the second, a girl, during her treatment for the angular projection of the spine; and the third, a girl, after having been cured of excurvature of the spine and sent into the country." Some of the old authors believed that the disease not infrequently commenced in the intervertebral cartilage. Mr. Stafford ("A Treatise on the Injuries, the Diseases, and the Distortion of the Spine," p. 154. London, 1832) says, in reference to the primary seat of inflammation in disease of the vertebræ: "Although it has been before stated that inflammation, ulceration, and scrofulous disease generally begin in the bones, yet in some instances they have appeared to commence in the cartilage. There are some cases in the museum of St. Bartholomew's which will prove that it first began in this structure. In one preparation, particularly, every one of the intervertebral substances throughout the whole column are entirely destroyed by ulceration, whilst most of the bones are only slightly affected by ulceration on their anterior surfaces. Thus, the bodies of the vertebræ rest one upon another without having the intervertebral substances between them." It is now generally conceded that tubercular spondylitis never begins in the cartilage, and only seldom affects the periosteum primarily, but that in nearly all cases the primary starting-point is in the bone itself. If the disease take an unfavorable course the granulations undergo cheesy degeneration, and gradually an abscess forms, which descends in a downward direction on the sides or in front of the vertebræ, which may present itself in the lumbar region as a *lumbar abscess*, or in the iliac fossa as an *iliac abscess*, or, if it follow the psoas magnus as far as Poupart's ligament or below it, as a *psoas abscess*. Penzoldt ("Ueber die von Brustwir belcaries ausgehende Œsophagusperforation und ihre Erkennung." Virchow's *Archiv*,

B. lxxxvi, p. 448) reports three cases where the abscess, forming in the course of dorsal spondylitis, perforated into the œsophagus. In two of these cases the symptoms did not point to the existing condition, while in the third the abscess, by compressing the œsophagus, gave rise to a complexus of symptoms which indicated the migration of the abscess toward the œsophagus. In spondylitis of the cervical vertebræ the abscess may present itself in the pharynx or on the sides of the neck. The spinal cord is well protected against invasion by its coverings, but it occasionally becomes implicated by direct extension of the disease or by compression in acute posterior curvature of the spine. Most frequently a tubercular pachymeningitis complicates the disease, but sometimes all of the envelopes and even the cord itself is involved. Inflammation of the spinal nerves at their point of exit from the vertebral column is also one of the complications of tubercular spondylitis, giving rise to peripheral symptoms which point to an affection of the nerve-roots.

Symptoms and Diagnosis.—The early symptoms, before the appearance of deformity, are often very uncertain and ill defined. The first symptom to attract attention is

Pain.—As the patients are usually young children, it is very difficult to locate the symptoms before the appearance of the characteristic deformity, as the inflamed part, if located below the cervical vertebræ, is not accessible to direct examination. Children complain usually of pain about the region of the stomach, at the periphery of the spinal nerves taking their exit from the inflamed vertebræ, instead of in the back. This pain is aggravated by flexion of the spine, by a misstep, and other movements which increase the pressure at the seat of disease, while extension of the spine affords relief. The position of the patient must be regarded as an early diagnostic sign. The child stands and walks erect, with the shoulders thrown back, and is unwilling to bend the spine forward when asked to pick up an article from the floor. This act is performed by squatting down instead of bending the spine.

Mr. Copeland ("Observations on the Symptoms and Treatment of the Diseased Spine," p. 35. London, 1815) has great confidence in the application to the spine of a sponge wrung out of hot water and passing it along the spine, in the detection of an incipient inflammation in one or more of the vertebræ. He says: "A sponge wrung out of hot water and carried down the spine will often give a very acute degree of pain while passing over the part where disease is going on. The effect of this experiment I first discovered by accident, when I had been applying leeches to a diseased spine; the gentleman, who was my patient, complained of great pain when the hot sponge came close to the projecting vertebræ; and, on reflecting how much more sensible of the power of heat an inflamed part was, I was led to repeat the experiment in every case of diseased spine which offered to my inspection. . . . This, however, may be safely concluded, that, although the absence of pain on this application of heat is not an evidence that there is no disease, the feeling of acute sensation in any one part is sufficient to mark that part as the seat of the disease." The increased reflex irritability often associated with inflammation of the vertebræ, more especially after the inflammation has extended to the envelopes of the cord, gives rise to peripheral symptoms which point to the central lesion.

Stanley ("A Treatise on Diseases of the Bones." London, 1849) alludes, in the following passages, to the distant and visceral symptoms associated with disease of the vertebræ: "Other modifications in the nervous affection are occasionally observed; thus, the irritation of the spinal cord, instead of taking its usual course downward and affecting the parts below the disease, has, in rare cases, traveled upward, so that disease in the lower dorsal vertebræ has chiefly affected the nerves of the upper limbs. The internal organs, especially of the abdomen and pelvis, variously participate in the nervous derangements ensuing from disease in the spine, and manifest either a slowness of their action or an apparent increase of their sensibility;

the latter more particularly occurring in the mucous surface of the bladder and intestines, which, in some cases, become so susceptible of slight impressions that the mere touch of the inside of the bladder by a catheter, or the slight stimulation of the intestines by a purgative, will directly be followed by severe spasms in the limbs."

Kyphosis.—Posterior curvature of the spine takes place as soon as one or more of the bodies of the vertebræ have become partially destroyed by the disease, and the latter involves a portion

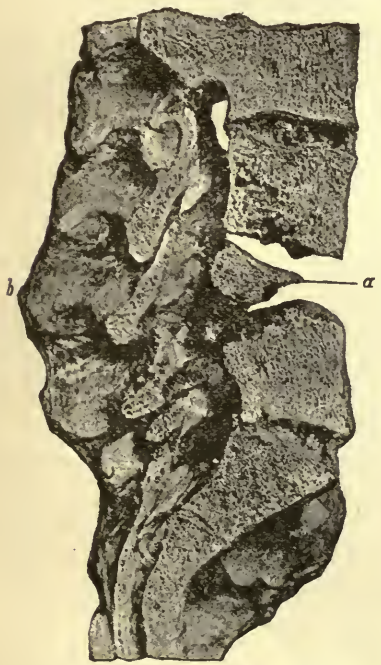

FIG. 44.—VERTICAL SECTION THROUGH SPINAL COLUMN. One-half natural size. (*Krause.*)

a, cuneiform destruction of the fourth lumbar vertebra; *b*, spinous process of this vertebra projects behind.

FIG. 45.—EXTENSIVE TUBERCULAR DESTRUCTION OF THE BODIES OF A NUMBER OF ADJOINING DORSAL VERTEBRÆ, CAUSING A LONG POSTERIOR CURVE INSTEAD OF AN ANGULAR GIBBUS. One-half natural size. (*Krause.*)

of the spine where this displacement can take place. The most extensive curves take place in the dorsal region. The extent of the curve is not a reliable indication as to the number of vertebræ involved, as, if the disease is superficial, a large section of the spinal column may be affected and yet posterior curvature is absent.

A sharp curvature indicates that not more than one, two, or three vertebræ are affected, while the absence of a sharp projection and a gentle curve of the spine point to an extensive disease of the spine involving from three to a dozen or more of adjoining vertebræ.

FIG. 46.—SHARP ANGULAR CURVATURE OF SPINE, CAUSED BY EXTENSIVE DESTRUCTION OF THE NINTH DORSAL VERTEBRA, OF WHICH ONLY A SMALL TRIANGULAR PIECE REMAINS AT *a*; AT THIS POINT A FISTULOUS OPENING LEADS INTO A PSOAS ABSCESS. (*Krause.*)

Usually, the curvature appears gradually, the bodies of the softened and diseased vertebræ yielding under the superimposed weight of the body by degrees; but occasionally the deformity comes on suddenly, simulating a pathological fracture or dislocation. This accident occurs often upon the slightest application

of force, and is followed by symptoms referable to compression of the spinal cord. In the case reported by Bulckley (*British Medical Journal*, vol. i, p. 517, 1880), a focus was located in the second cervical vertebra, at the base of the odontoid process, in a child 7 years of age, which had nearly destroyed the attachment of this process to the remaining portion of the bone, and which was fractured by a slight blow upon the back. The fractured process was dislocated in the direction of the cord, and the accident produced sudden death. The pressure of the weight of the body exerts itself mostly upon the anterior portion of the inflamed vertebræ, where pressure-atrophy is caused first, giving rise to wedge-shaped loss of substance in one or more of the vertebræ, which determines posterior curvature, the production of which is, of course, hastened by the destruction of bone by the tubercular inflammation.

Progressive growth of the gibbus is prevented by the formation of new bone, and when other parts or proper mechanical appliances furnish the necessary support for the weight of the body above the diseased vertebræ.

Scoliosis. — Lovett (*British Medical Journal*, vol. cxxii, No. 15) made careful observations upon some thirty cases of spinal caries in reference to the early appearance of deformities. He finds that in untreated cases the presence of lateral deviation is universal. In order to detect this deviation of the spine it is necessary to strip the patient and look at him from the front. The deformity consists in a distinct leaning of the body toward one side or the other rather than a sinuous distortion. This leaning is most frequently toward the right, and is of diagnostic value because it is one of the earliest symptoms of Pott's disease. Rotation of the spine is never as well-marked as in scoliosis from other causes.

Paralysis.—Some doubt still remains as to the immediate cause of paralysis in cases of tubercular spondylitis. Many trace it to compression of the cord at the point of curvature of the spine (Fig. 46), while others believe that, in most instances,

it is due to implication of the cord and its envelopes in the inflammatory process.

Condroy de Lauréal ("Quelques considérations sur le mal vertébral chez l'enfant." Thèse, Paris, 1874) agrees with Bouvier, that, with the exception of the cervical region, paraplegia as a complication of Pott's disease occurs only then, if the seat of the affection is in the first six of the dorsal vertebræ. In one hundred and thirty-six cases the disease was located in the lower dorsal and lumbar region, seventy-seven times in the dorsal alone. In the first cases paraplegia was observed only once, and in this case it followed a fall and disappeared two months later. In the last number of cases paraplegia was noted nineteen times, and of this number the seat of the disease involved sixteen times the upper dorsal vertebræ. The explanation of this, as given by the author, is the fact that the spinal canal in the upper dorsal region is very narrow as compared with the rest of the column.

Mr. Stafford (*ibid.*, p. 166), in discussing the causes of paraplegia as a complication of Pott's disease of the spine, refers to both the effects of mechanical compression and the textural changes of the cord and its meninges: "It may be observed also, in most of the morbid specimens of this disease, that the vertebral canal, where the curvature takes place, is even larger than natural, and that the projecting points of the broken-down vertebræ are absorbed and rounded off. In some cases, no doubt, where only one or two bodies are destroyed and the angle is very acute, the bones may press upon the spinal cord, but in the majority they do not; if the patient live long enough, there is but little doubt they are, in general, gradually smoothed down by absorption. The state of the medulla itself, if examined after death of the part where the curve takes place, varies; sometimes it does not in any way deviate from health; the structure both of the medulla and its membranes is natural, while at other times a considerable degree of disease may have gone on. The membranes may be thickened, matter may be formed pressing upon them, or between them, and the medulla itself may be

reddened, or partially softened, or softened in such a manner as to be almost in a fluid state. In these cases the paralysis below is usually complete."

Symptoms.—Courjon ("Étude sur la paraplégie dans le mal de Pott." Paris, 1875) regards the paraplegia occurring in the course of Pott's disease of the spine not as the result of mechanical pressure upon the cord, but as an evidence that the disease has extended to the structures of the meninges and the cord itself, giving rise to structural changes. The degree of the gibbus does not necessarily determine the paralysis, as this may take place if the projection is but slight. A cure may be effected even if the deviation of the vertebral column is not changed.

Kahler ("Zur Symptomatologie der Rückenmarks compression bei tuberkulöser Caries der unteren Halswirbel." *Prager Med. Wochenschrift*, B. viii, Nos. 47–50, 1883) has studied this subject with special reference to affections of the lower cervical vertebræ. A *pachymeningitis externa caseosa* complicating the disease of the vertebræ is attended by pain in the arms and partial loss of sensation during the early stages, to be followed later by atrophy of some of the muscles of the arms and shoulders, with diminution of irritability to the electric current. In some cases, paralysis and anæsthesia of the extremities and trunk develop rapidly, followed by incontinence of the sphincters, diffuse muscular atrophy, decubitus, and death. Motor disturbances, both from compression and direct extension of the disease, are more frequently observed than loss of sensation, because both of these causes act with greater intensity upon the anterior than posterior segment of the cord.

Contractions of the lower extremity occasionally present themselves as peripheral manifestations of the central nervous lesion. Reflex function of the cord is usually preserved, even if the paralysis is complete; but if the progressive paralysis is attended by secondary myelitis, reflex action gradually disappears. In sudden displacements of the diseased vertebræ the paralysis

sets in quickly, but is not always caused by compression, as the displacement of the diseased bones is often speedily followed by myelitis.

Temperature.—Although fever is not usually present in chronic spondylitis, it very often attends acute cases. Lovett ("The Diagnosis of Pott's Disease." *American Journal Medical Sciences*, December, 1891) has recently called attention to high evening temperature as a constant symptom in the acute stages of tubercular spondylitis. According to his observations the rise of temperature is from one to three degrees, and in general it can be accepted as indicating roughly the degree of severity of the disease. The temperature did not seem to be influenced by the formation of abscess.

Prognosis.—As a rule, tuberculosis of the spine pursues a chronic course, but exceptionally it appears as an acute affection attended by fever and other symptoms suggesting a general disease. Patients may die in a short time, and the diagnosis of a diffuse acute tubercular spondylitis is only made in the post-mortem room. The prognosis is always more favorable in children than adults. Abscess adds to the gravity of the case. Bampfield ("An Essay on Curvature and Diseases of the Spine," etc., p. 85. London, 1824) was well aware of the dangers which attend the formation of an abscess in connection with Pott's disease, as can be learned from the following sentence: "When curvature is caused by caries of the vertebræ or gangrenous destruction of the intervertebral substance, the prognosis should be unfavorable, and if caries be combined with the appearance of external abscess communicating with the diseased vertebræ, whether the abscess have the name of lumbar, psoas, or any other appellation or situation."

Townsend ("The Treatment of Abscesses of Pott's Disease." *Medical News*, December 19, 1891) gives the ultimate result in seventy-five cases of abscess of the spine, and from the tables given it would appear that the prognosis in such cases is not as favorable as has generally been supposed:—

ANALYSIS OF SEVENTY-FIVE CASES OF ABSCESSES OF POTT'S DISEASE.

No treatment but brace;	abscess disappeared,	3
" " " "	abscess in statu quo,	8
" " " "	abscess increasing, child doing well,	8
" " " "	child not doing well,	2
		21

ASPIRATION.

Abscess disappeared,	11
Abscess opened spontaneously after aspiration failed,	3
Abscess incised after aspiration failed,	4
Abscess in statu quo after aspiration failed,	1
	19

Number of aspirations in each case, from 2 to 6,—average 3.

INCISIONS—SCRAPING SAC.

With use of iodoform-emulsion or peroxide of hydrogen,		14
Results, good,	11	
Results, bad,	3	
Infected at time of operation or at subsequent dressings,	11	
Not infected,	3	

OPENED SPONTANEOUSLY.

Results, good,	15	
Results, bad,	6	
		21
		75

DEATHS.

Tubercular meningitis,	2
Amyloid liver,	2
Suppression of urine,	1
	5

The symptoms are often misleading, as to the final outcome. Thus, König observed two cases of tubercular spondylitis in the lower cervical vertebræ, in children, which had resulted in complete paraplegia, and yet both patients recovered completely. A process of repair may be initiated at any time. If the dorsal vertebræ are affected and a well-marked posterior curvature of the spine has taken place, the ribs finally furnish the necessary support and these rest again on the pelvis; and when the inflamed parts are in a condition of rest and immobilization, a plastic or reparative process is substituted for the destructive lesion, and recovery by bony ankylosis results. If a migrating abscess communicating with diseased vertebræ open spontaneously, or infection take place after incision and drainage, the

prognosis is always rendered dubious. Secondary infection with pus-microbes leads to profuse suppuration, hectic fever, and, if death does not occur from these complications, danger to life is threatened later from amyloid degeneration of internal organs. Spontaneous elimination of necrosed bone may take place, followed by recovery. This favorable termination has been repeatedly observed in disease of the upper cervical region, when recovery followed after the escape of sequestra from the atlas or epistropheus through a fistula in the pharynx. In reference to deformity, it can be said that well-directed mechanical treatment can do a great deal against the prevention of posterior curvature, but the same treatment is powerless in correcting it. On the whole, the outlook in cases of tubercular spondylitis is anything but encouraging. Boeckel gives an account of eight cases, and among them not a single case of complete recovery,—two local relapses and five deaths from pulmonary tuberculosis, and in one case the final result was not known. Even in cases where the patients have apparently recovered, relapse may take place at any time, and it is seldom that a child who suffers from this disease reaches old age.

Treatment. — As tubercular lesions in the bodies of the vertebra and in the joints between them are inaccessible to direct surgical interference, the treatment to be relied upon in these cases must consist in supporting the patient's strength by a liberal diet, out-door air, and the internal use of tonic and nutritive remedies, subcutaneous medication and the employment of mechanical measures to secure rest for the diseased vertebræ.

Counter-irritation.—This method of treatment is mentioned here simply for the purpose of giving the treatment of Mr. Pott, who describes (*loc. cit.*, p. 471) his method of cure as follows: "It consists merely in procuring a large discharge of matter from underneath the membrana adiposa, on each side of the distempered bones, forming a curvature, and in maintaining such discharge until the patient shall have recovered his health and

limb." He strongly disapproves of the application of any mechanical instrument whatever, and has no faith in the internal use of drugs. Mr. Sheldrake ("A Treatise on Diseased Spine," p. 17. London, 1816) adopted the treatment advised by Mr. Pott, but combined it with the employment of mechanical appliances. It is fortunate that counter-irritation in the treatment of tuberculosis of the spine as well as of other bones has been abandoned long ago, and it is safe to predict that it will never come into use again. It is difficult to conceive how much suffering and misery was inflicted by this method of treatment upon a class of patients least calculated to bear such treatment.

Rest and Extension. — Rest and extension are the two essential conditions which place the inflamed vertebræ in the most favorable condition for the substitution of a reparative for a destructive process, as well as in the prevention of deformity. These requirements in the treatment of tubercular spondylitis can only be fully realized by keeping the patient in the supine position, and to a lesser extent by efficient mechanical support and immobilization of the spine. In dwelling on the importance of lifting the weight of the body off from the diseased vertebræ, Mr. Bampfield ("An Essay on Curvature and Diseases of the Spine," etc., p. 130. London, 1824), in his interesting work, gives the following directions: "For the correct and clear comprehension, therefore, of the terms and operations mentioned in this dissertation, it is necessary to state that three variations of the horizontal position will be employed in the treatment,—the dorsal horizontal position, or lying on the back; the facial horizontal position, being the reverse of the former, or what in common language is called 'lying on the face,' of course, in a line with the sternum and linea alba abdominis; the lateral horizontal position, or lying on either side. Time required by this treatment, from three to six months." In speaking of extension the same author (*op. cit.*, p. 130) says: "Some machine makers, to whom deformed persons resort for their cure, *suspend their patients by their necks, through the medium of ropes and*

compound pulleys, by which they presume they can straighten their spines (italics my own); but, besides that the practice is dangerous in cases where the bodies of the vertebæ are carious or destroyed, it has more effect in stretching the ligaments and increasing the size of the muscles of the neck which are principally called into action by the position than it has in curing the deformity." The dorsal horizontal position should be advised in all cases that appear to pursue a rapid course, and whenever the patient suffers acute pain. The patient should be placed in a

FIG. 47.—SPONDYLITIS OF MIDDLE DORSAL VERTEBRÆ. RAUCHFUSS'S APPARATUS COMBINED WITH HEAD-EXTENSION BY GLISSON'S SWING. (*Krause.*)

single bed provided with a smooth hair mattress, and extension can be made at the same time by placing him upon Rauchfuss's swing.

Rauchfuss's extension bandage consists of a strip of cloth from six to eight inches in width, which is fastened to each side of the bed a few inches above the mattress, and upon which the patient is placed in such a manner that the curvature rests upon the centre of the swing.

At the second meeting of the American Congress of Physicians and Surgeons, the treatment of spondylitis received a

great deal of attention in the Orthopædic Section. Weigel, of Rochester, and Vance, of Louisville, strongly advised rest in the recumbent position until the active symptoms have subsided. Foster, of Cambridge, combines this treatment with extension, especially if the disease involve the cervical vertebræ. Extension is obtained by weights, the cords running over the head and foot of the bed, and being attached to waist-belts, chest-belts, or Sayre head-straps. In spondylitis of the cervical vertebræ rest in bed can be combined with extension by means of weight and pulley, as advised by Volkmann. (Fig. 47). If the

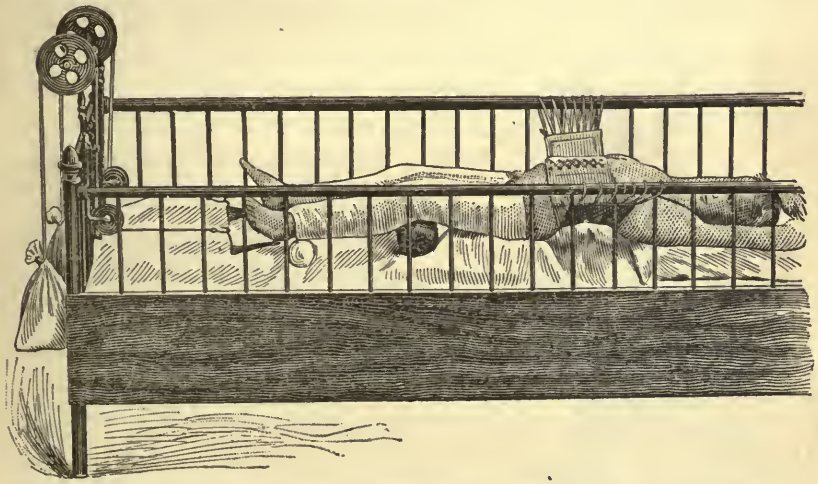

FIG. 48.—CARIES OF LOWER LUMBAR VERTEBRÆ RAUCHFUSS'S APPARATUS WITH EXTENSION ON BOTH LEGS. (*Krause.*)

disease is located in the lumbar or lower dorsal region, extension can be most effectually applied by placing the patient in the dorsal supine position, the gibbus resting on Rauchfuss's apparatus and moderate extension by weight and pulley on both legs.

Rest in bed should be enforced until the active symptoms of inflammation have subsided, which will be indicated by subsidence of pain. At this time a portable apparatus should be applied. I will not occupy space uselessly by giving descriptions of the numerous machines which have been devised for this purpose, as none of them have answered the expectations.

Sayre's plaster-of-Paris jacket, applied while the patient is partly suspended, answers a more useful purpose than any of the numerous complicated and expensive apparatuses which have been, as yet, invented.

To apply the jacket properly requires a great deal of experience and the exercise of considerable skill. In many communities this method of treatment has become unpopular, both among physicians and the laity, from the bad results caused by improper application of the corset.

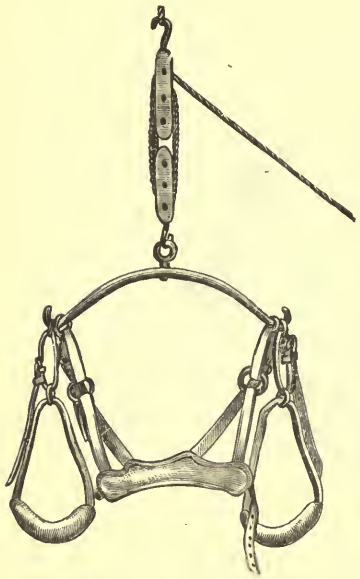

FIG. 49.—SAYRE'S SUSPENSION APPARATUS.

Hyperextension must be carefully avoided, and when old enough the patient must be instructed to extend himself only to the point where pain is relieved, and not beyond this point, which well deserves the designation "point of comfort." The bony prominence at the seat of curvature must be carefully protected against pressure by applying, on each side, a firm pad sufficiently thick to prevent contact of the projecting spinous processes with the plaster cast. The plaster bandages, freshly prepared, are immersed in lukewarm water until carbonic acid ceases to escape, when they are smoothly applied, so that after extension is removed the cast will be accurately molded to the unequal surface of the body. The body should be protected by a knit, closely-fitting shirt. If the disease is located in a cervical or upper dorsal vertebra, extension is made by a jury-mast.

Another matter of great importance is to see the patient from time to time, in order to determine whether the jacket causes injurious pressure at any point, which, if this should be the case, is remedied at once, either by cutting out that portion of

the jacket which has caused the decubitus or by applying a new one. It is necessary to renew the jacket every six to twelve weeks, as in that time it becomes loose and no longer furnishes the requisite mechanical support. Felt and other plastic material has been used as a substitute for plaster-of-Paris, but none of them have proved superior to this material when properly used, and all of them require more time and skill in their application. The mechanical treatment by extension and fixation must be continued several months after all inflam-

FIG. 50.—CHILD SUSPENDED AND READY FOR APPLICATION OF PLASTER-OF-PARIS BANDAGE.

FIG. 51.—SPONDYLITIS OF UPPER DORSAL VERTEBRÆ. SAYRE'S PLASTER-OF-PARIS JACKET, WITH JURY-MAST. VOLKMANN'S WALKING-STOOL. (*Krause.*)

matory symptoms have subsided, as too early suspension of this part of treatment has often been followed by a local relapse.

Iodoformization of Abscess.—The value of subcutaneous iodoformization has been most apparent in the treatment of tuber-

cular abscesses originating from diseased vertebræ. No modern progressive surgeon, at the present time, would entertain the idea for a moment of resorting to operative procedures without having given this method of treatment a fair trial. I regard this treatment as one of the greatest advances in the struggle against tubercular affections of inaccessible bones like the vertebræ. In my own hands it has yielded brilliant results in cases that without it would certainly have been hopeless. I have seen iliac, lumbar, and psoas abscesses, the size of a child's head, in communication with tubercular disease of the vertebræ, definitely heal after three or four evacuations, followed by irrigation and injection of a 10-per-cent. emulsion of iodoform in glycerin.

Bruns (*Beiträge f. klinische Chirurgie*, B. iv, Heft 1) has collected thirty-five cases of tubercular abscess, originating in the vertebræ and presenting themselves clinically as psoas abscesses, treated by iodoform injections; twenty-four of this number were completely cured, five improved, and in two the result remains unknown. The author concludes, from these figures and his own experience, that the iodoform treatment of these abscesses is most encouraging. Bonilly injects sinuses with chloride-of-zinc solution, and Verneuil uses iodoform ether, Schede corrosive sublimate, Périér salol ether, and Reboul naphthol camphor for the same purpose. Heuter advised parenchymatous injections into and around the diseased vertebræ of solutions of carbolic acid as early as 1879. I cannot recommend too strongly the method of subcutaneous injection of iodoform after evacuation of tubercular abscesses in the treatment of tuberculosis of the spine. For further information regarding the technique of the procedure the reader is referred to the chapter in which this subject is fully discussed.

Operative Treatment.—The operative treatment of tubercular spondylitis has for its objects the modern management of the abscess, after such has formed, and the removal of the immediate causes of compression if the disease has produced paralysis by compression of the spinal cord or by extension to its

coverings. Lannelongue favored opening and scraping of cold abscesses developing in connection with diseased vertebræ in 1881, and Reclus adopted this plan of treatment in 1886. This treatment was later indorsed by Bouilly, Socin, Boeckel, Volkmann, Lesser, Routier, Quenu, and Leriche. The protection afforded by following strict antiseptic precautions during and after the operation reduced the danger of this procedure, but did not displace it, and at the present time few would dare to open an abscess still remaining in communication with tubercular foci in the spine. In my own practice I have succeeded twice in preventing infection subsequently after opening and scraping a lumbar abscess, and definite healing was obtained without a drop of pus; but more frequently I have only been able to maintain an aseptic condition for a number of weeks, when finally infection occurred during the dressing or by displacement of the dressing, and profuse suppuration set in, with all the immediate and remote consequences. Incision and scraping should only be resorted to when the abscess threatens to open spontaneously; *in such cases it is not only proper, but absolutely necessary, to interfere, in order to secure for the interior of the abscess and the primary foci in the bones an aseptic condition.* Attempts have been repeatedly made to attack the primary bone disease. Boeckel (*Gaz. heb. de Strassburg*) made an *évidement vertebrale* in 1882; Israel (*Berl. klin Wochenschrift*, March 9, 1882) scraped the body of the twelfth dorsal vertebra the same year; Polaillon (*Union Médicale*) resected two spinous apophyses in 1883; Delorme (*Thèse de Faucillon*, 1887) scraped the body of the twelfth dorsal vertebra, and Labbé attacked one of the sacral vertebræ for a tubercular affection.

Chipault (*Archiv Gén. de Méd.*, December, 1890) has collected thirty-five cases of Pott's disease treated surgically, and he states that out of this number twenty were improved or definitely cured. In the cases where the operation proved successful, progress toward recovery went on slowly, but uninterruptedly. When the operation was done for paralysis sensation re-appeared,

first from above downward; motion later, and in an opposite direction. The sphincters recovered early. The fifteen cases not improved divide themselves into two groups,—(*a*) those in which primary improvement is followed by return of symptoms, and (*b*) those in which the operation is without effect. In the first group the cause of recurrence may be the supervention of acute curvature, or the re-growth of granulations. The second source of failure is, in some cases, an incomplete removal of granulations; in others, possibly, a too great destruction of the cord-tissue. Of ten deaths, three were due to injury to the cord at the time of operation, four to general tuberculosis, and two to the severity of pre-existing complications.

The author concludes that we should operate only when the general health is good, and when the spinal symptoms are severe and do not yield to other treatment. Children do much better than adults. Of bad prognostic import is a high position or extensive distribution of the disease. Scraping of fistulous tracts should be carried as far toward the primary starting-point of the abscess as possible, and must always be done under strictest antiseptic precautions. If necessary, counter-openings can be made. Iodoform tampon and secondary suturing will give better results than immediate suturing and tubular drainage.

Laminectomy or Lamnectomy.—This operation was first suggested by Heister ("A General System of Surgery." Seventh edition, Book I, Chapter vi, p. 143. London, 1745), while the first attempt to remove depressed fragments of a broken arch was made by Louis (Chipault, *Gaz. des Hôp*, p. 809, September 13, 1890). The first well-planned and intentional operation on the spine for subcutaneous lesion was performed by Mr. Henry Cline (South's *Chelius*, vol. i, p. 539. London, 1847).

Macewen, in 1888 (*British Medical Journal*, August 11th), reported a number of cases of paralysis resulting from compression in Pott's disease of the spine, benefited and cured by removing two or more of the arches of the vertebræ. Only in exceptional cases is the mechanical pressure the only cause of

paralysis. If the paralysis appear suddenly, it is the result of a slipping of the diseased vertebræ upon each other,—spondylolisthesis,—in which case operative interference would not be justifiable. Replacement by extension is the thing to be attempted. The extension of the tubercular process toward the cord is impeded first by the periosteum; but after this barrier has been overcome, the epidural space, with its loose cellular tissue, furnishes a good locality for the diffusion of the tubercular process. The inflammatory product is often quite copious in this place, and pushes the dura in the direction of the cord. Sometimes a real tubercular abscess develops here. The dura offers great resistance to the progress of the disease, but finally becomes implicated and a tubercular pachymeningitis is the result, preceded by a peri-pachymeningitis. The tubercular process extends itself first on the outer surface, causing a pachymeningitis externa, and the internal surface is seldom found affected; if, however, the patient live long enough, the disease finally penetrates the membrane. Compression of the cord often takes place in a sufficient degree before the dura is involved.

Schmaus ("Die Compressions Myelitis bei Caries der Wirbelsäule." Wiesbaden, 1890) gives an account of fifty-two post-mortem examinations of spondylitic paralysis. Among these, not less than thirty-two showed well-marked evidences of compression of the cord. Kahler ("Ueber die Veränderungen, welche sich im Rückenmarke in Folge einer geringgradigen Compression entwickeln." *Zeitschrift für Heilkunde*, B. iii. Prag, 1882) has shown experimentally that a very slight degree of compression of the cord is followed by œdema and structural changes leading to paralysis. In consequence of such vascular changes the nerve-elements degenerate, and their place is taken by connective tissue. He has demonstrated that a moderate encroachment upon the spinal cord cannot endanger its function, provided anatomical structure is not interfered with.

Strümpell has claimed, on good grounds, that compression

myelitis in reality is not an inflammatory but a degenerative process. In some cases, however, the disease reaches the pia and cord itself, and then the designation *myelitis tuberculosa* would be proper. If paralysis is found without much displacement of vertebræ, it must be caused by compression from inflammatory product within the canal. Of the fifty-two cases reported by Schmaus, the cause of compression is specified in thirty-nine. Among these it was due to a caseous pachymeningitis in thirty-three; six times it was caused by deviation of the affected vertebræ. The operation of opening the spinal canal should not be undertaken without positive indications. Gradual increase of paralysis points to compression from inflammatory product within the canal, and this supposition is sustained if the disease is attended by symptoms which point to an affection of the roots of the spinal nerves. Operation should be preceded by extension treatment.

Kraske ("Operative Eröffnung des Wirbelcanales bei spondylitischen Lähmungen." *Archiv f. klinische Chirurgie*) has written a very valuable and practical monograph on the surgical treatment of paraplegia resulting from spondylitis. He bases his remarks on a study of the pathological conditions of seventy cases. The author differs from Macewen and the majority of surgeons who attribute the paralysis to compression of the cord, and advances the idea that the paralysis does not result from compression, but from participation of the cord or its meninges in the inflammatory process, and on this account he urges that, even with the most positive diagnosis, operative treatment should be preceded by persistent local treatment in a reclining position.

In illustration of the treatment outlined by him, and as samples of the pathological conditions which the surgeon has to deal with in these cases, I will briefly outline the four cases that came under Kraske's personal observation. The first case was a woman 57 years old, who had already passed through several multiple tubercular affections. She was suddenly attacked by

pain in the thoracic portion of the spine, chiefly radiating to the right and soon followed by complete paraplegia. There was no curvature, but tenderness on pressure upon the fifth and sixth spinous processes. The formation of an abscess at this place invited prompt action. The abscess was freely incised and scraped. The arch of the fifth dorsal vertebra, having undergone extensive tubercular destruction, was removed. Underneath the arch a teaspoonful of tubercular pus and a mass of granulation tissue were found. After the removal of the granulations from the outer surface of the dura, the pulsations of the cord could be distinctly seen and felt. The granulations and abscess were epidural. The paralysis disappeared in a few days. In a month the patient left the bed and commenced to walk. However, the improvement was of short duration; the paralysis soon returned, and death resulted from pulmonary phthisis in seven months. The necropsy revealed tuberculosis of one of the bodies of the dorsal vertebræ and compression of the cord by its lower edge.

In the second case, a man aged 33 years, the disease commenced with a violent pain between the second and fifth dorsal vertebræ, radiating toward the right side, followed by paraplegia, incontinence of bladder, rectum, and decubitus. No kyphosis, but an abscess formed on the right side of the spine. Abscess opened and scraped. Resection of second, third, and fourth arches of dorsal vertebræ. No improvement, and death in eight weeks. Post-mortem examination revealed more extensive disease than was found at the time of operation. Massive granulations and head of fourth rib on right side encased by a tubercular abscess. From here the disease had extended into the vertebral canal through the intervertebral foramina.

The third and fourth cases had some essential points in common. Their ages 12 and 14 years; gibbosities at the same place; paralysis developed with root symptoms. Rest in recumbent position was not followed by any improvement. Resection of the arches of the third and fourth dorsal vertebræ. Tubercu-

lar pachymeningitis occupied the space exposed. The fungous granulations were removed with the sharp spoon, and at the same time minute tubercular sequestra were removed. In one of these cases prompt improvement of all the symptoms followed the operation. Sensation returned at once, and motion was restored gradually. In about two months the paralysis had practically subsided. After a short period the paralysis returned and the wound, which had healed, reopened, and another curetting proved likewise a failure. The patient was still living at the time the report was made. In the other case the improvement was slower, but equally decisive. At the end of a week the boy could lift and move the lower extremities. The improvement continued for about a month, when the symptoms became aggravated, and subsequently the symptoms varied very much, but, on the whole, the patient was greatly benefited by the operation.

Hoffa (*International Journal of Surgery*, October, 1891) has collected thirteen operations within the vertebral canal. Two died at once, two recovered, and would probably have done so without operation. In the others there were immediate good results, but relapses soon occurred. In his estimation, lamnectomy has no great future before it, and should be limited to those cases in which the processes alone are effected.

De Forest Willard, in a paper entitled "The Operative Treatment of Tuberculous Caries of the Spine," read at the second meeting of the American Congress of Physicians and Surgeons, expresses himself in a very guarded manner in reference to laminectomy. He maintains that for the relief of pressure-paralysis the laminæ are to be removed only after a thorough trial and failure of long-continued horizontal extension, counter-extension, and fixation. In the majority of cases recovery takes place after extension and mechanical treatment. He regards laminectomy as a difficult operation, except in the upper dorsal region, and one that is entailed by considerable risk to life. In caries of the arches, and when the cord is compressed from behind, the operation is justifiable and promises good results.

When the pressure is anterior, either from the deposit of caseous material from tubercular infiltration or from inflammatory deposit, no permanent benefit will be secured, even though temporary gain is apparent. White, in his recent valuable paper on "Spinal Surgery" (*Therapeutic Gazette*, October, 1891), gives the analysis of forty cases of this operation for tubercular spondylitis, which are all the author was able to bring together. Of this number twenty-two were either materially improved or absolutely cured. The unsuccessful cases which recovered from the operation were, in some instances, the subject of secondary disease. The deaths were twelve in number, showing a mortality of 30 per cent., and were due to various causes, such as shock, or extensive renal and pulmonary disease. In others, death was directly due to the gravity of the disease of the cord.

Mr. Arbuthnot Lane (*British Medical Journal*, October 31, 1891) is a strong supporter of lamnectomy in the treatment of tubercular spondylitis complicated by paraplegia. He recently reported eleven cases, in which this operation had been performed by himself, to the London Clinical Society. In all but one case the cord was found compressed by an abscess. He is of the opinion that several of the cases would have died from secondary lesions without the operation. Only in one case was death attributable to the operation, and this was a child in a very feeble condition. Only in one case was the subsequent formation of tubercular material so rapid as to obliterate very quickly the benefit derived from the two operations. In most of the cases the cord was compressed about the level of the fifth or sixth dorsal vertebra. From his experience he is satisfied that operative interference involved very slight risk; it was followed by very little pain; it relieved the patient of the compression symptoms, and, lastly, it enabled the surgeon to treat the diseased vertebræ directly,—not only by spooning, irrigation, and the thorough removal of all carious bone, but also by the repeated local application of iodoform, from which he believed he had obtained the greatest benefit. At the same

meeting Mr. Bowlby said that, in a case which he had submitted to operation two years ago, no pus was found, but the patient made a rapid recovery, although before operation he had been kept quiet for a long time without improvement. In another case, done six weeks ago, in which no pus was found and not much benefit was anticipated, the patient had begun a week subsequently to move the foot, and now, after six weeks, the paraplegia was greatly relieved; the spine, however, was growing more bent. He did not believe that diseased tissue of the bodies of the affected vertebræ could be removed to any considerable extent, as the roots of the nerves and other parts intervened between the site of operation and the real disease. The utility of lamnectomy in the treatment of spondylitic paraplegia can only be determined by a more careful study and comparison of cases that recover spontaneously, and more extensive statistics of the immediate and functional results following the operation. It is evident that one of the indications of the operation is to remove the tubercular material as thoroughly as possible, more especially if the disease has extended to the meninges of the cord. More frequently than has been heretofore supposed these are implicated, and should receive proper attention after removal of a sufficient number of the vertebral arches.

CHAPTER XXXIII.

Tuberculosis of Pelvic Bones, Scapula, Clavicle, Sternum, and Ribs.

Pelvic Bones.—Tuberculosis of the pelvic bones has, for well-founded reasons, always been regarded as a serious affection. Terrillon (*Medical and Surgical Reporter*, February 25, 1888) points out the fact that in early life, up to about 30 years, in tuberculosis of the ilium, the disease is always located at the centre of the bone, in or around the cotyloid cavity; while in older patients it develops in the peripheral parts, near the secondary centres of ossification. He urges early operative treatment to prevent involvement of large areas and the burrowing of pus, which he has seen travel as far as the neighborhood of the popliteal space. If the disease is extensive, the suppurating channels should be freely laid open and as much bone removed as is diseased or can be taken away with safety. In the event a tubercular focus is located near the acetabulum, an early operation would most effectually prevent secondary infection of the hip-joint. The crest of the ilium is quite frequently the seat of tubercular inflammation, and the operative treatment will often require quite an extensive resection of this part of the bone.

In the case of a girl 20 years of age, suffering from a long-standing fistula over the pubic symphysis, I found a tubercular focus, nearly the size of a walnut, between the pubic bones. The cartilage was almost completely destroyed. The cavity was thoroughly scraped out and packed with decalcified iodoformized bone-chips, and healed in a short time without suppuration. Thiéry (*loc. cit.*, p. 464) gives an account of three partial resections of the sacrum for tubercular affections, in patients 24, 26, and 36 years of age, respectively. One of these died of erysipelas eight months after the operation, a sinus still remaining; one died of phthisis two years later; the last case was

paraplegic, but could walk, by the aid of two sticks, six months after operation; no later information. The anterior surface of the sacrum is so inaccessible to operative treatment that when the disease is located here it would be better to rely on curetting and injections of iodoform or balsam of Peru than undertake a formidable operation. If the disease involve the posterior surface, radical operation should be attempted if mere expectant treatment has failed.

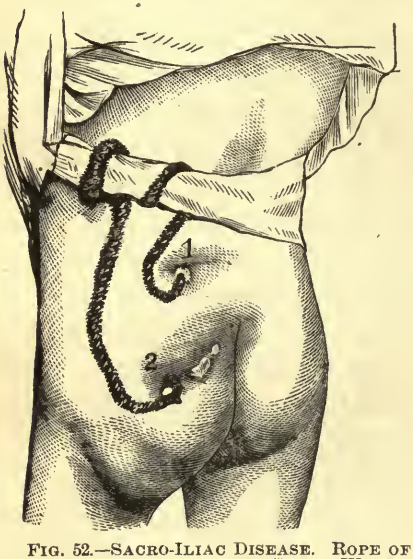

FIG. 52.—SACRO-ILIAC DISEASE. ROPE OF OAKUM PASSED THROUGH SINUS WHOLE LENGTH OF JOINT. (*Sayre.*)

Heath ("Clinical Lecture on Sacro-Iliac Disease." *Brit. Medical Journal*, December 16, 1876) reports three cases of tuberculosis of the sacro-iliac synchondrosis, and in all of them the process terminated in the formation of an abscess. The abscess was evacuated by aspiration, and two cases recovered, while the third remained under observation. He advises immobilization by a bandage composed of two compresses which are placed over the os pubes, from which circular belts pass around the pelvis which press the diseased surfaces against each other.

Through the writings of W. Van Hook ("Tuberculosis of the Sacro-Iliac Joint." *Annals of Surgery*, vol. viii, pp. 401–433, and vol. ix, pp. 35–54 and 150–180) and Hektoen ("Tuberculosis of Sacro-Iliac Joint." *North American Practitioner*, 1890) the attention of surgeons has been called to the feasibility of attacking the sacro-iliac joint in the treatment of tubercular affections in this locality. This joint is quite frequently the seat of tubercular inflammation, and after sinuses have formed a radical operation is indicated, provided the general condition

of the patient warrants such a procedure. Abscesses communicating with this joint can be treated by tapping and iodoform injections, with a good prospect of effecting a permanent cure. Years ago Sayre resorted to thorough drainage in such cases. For this purpose he used a rope of oakum saturated with balsam of Peru. (Figs. 52 and 53.)

This case made an excellent and permanent recovery. If an operation is determined upon, the sacro-iliac synchondrosis must be exposed by a large incision parallel to and directly over this joint, and, with chisel and hammer, sufficient bone removed from each side to expose the tubercular focus freely, which is

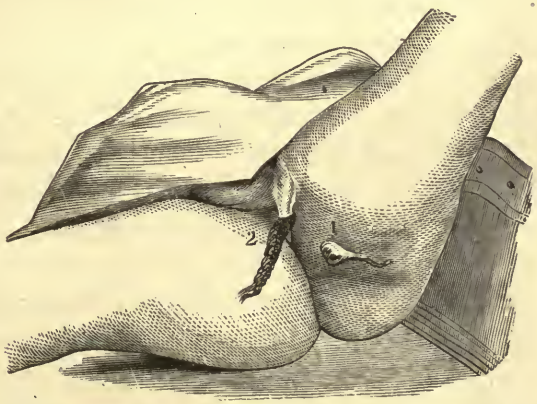

FIG. 53.—SAME CASE. SINUSES IN PERINEUM DRAINED IN SAME MANNER. (*Sayre.*)

then removed thoroughly with the sharp spoon. Iodoform-gauze tamponade and secondary suturing should take the place of primary suturing and tubular drainage.

Clavicle.—Tuberculosis of the clavicle is quite rare. The peripheral or periosteal form occurs, like a similar affection of the malar bone, in the shape of small, circumscribed, tubercular abscesses, with or without sequestration. Central tubercular osteomyelitis is very rare, and appears either as a diffuse infiltration, single or multiple foci. The diffuse form and multiple foci may render complete extirpation of the bone necessary. Two such cases were operated on successfully, by complete

extirpation of the bone, in the clinic at Halle, with good result. More frequently than the shaft of the bone, the sterno-clavicular articulation is affected. The disease appears here, as in other joints, either as a primary disease of the synovial membrane or the joint affection develops in consequence of the extension of an osseous focus in the manubrium of the sternum or the sternal end of the clavicle into the joint, when the usual symptoms of tumor albus appear in succession. From a diagnostic point it is important to remember that syphilitic affections of this joint are quite frequent, and closely simulate the clinical picture now under consideration. Tuberculosis of this joint is more frequently met with in adults than children, and not infrequently it attacks persons advanced in years. The oldest subject of this affection that has come under my notice was a woman, 72 years old, who gave no history of heredity. Six months before I examined her the lymphatic glands on left side of the neck became successively enlarged, followed later by caseation and formation of tubercular abscesses. About the same time the sterno-clavicular joint on the same side became tender, painful, and swollen, and terminated later in the formation of a large, cold abscess. This opened at two places in the course of a few weeks. Through the fistulous tracts a probe could be introduced into the joint and came in contact with the articular surfaces, denuded of their cartilage. Superficial foci of the shaft of the bone are easily and thoroughly removed by incision and scraping. If the bone contain multiple foci, or is diffusely infiltrated with tubercle or cheesy material, extirpation of the entire bone should be resorted to as soon as possible, before the disease has passed much beyond the loose connective tissue underneath the bone. Tuberculosis of the sterno-articular articulation is treated upon the same general principles as similar affections in other accessible joints. Injection of iodoform or balsam-of-Peru emulsion should receive a fair trial before the resulting tubercular abscess has opened or is to be opened for the purpose of making a radical operation. If a tubercular

abscess originating in this joint has opened and has left a fistulous tract, resection of the joint should be no longer postponed. I resected this joint successfully in one case of long-standing tuberculosis, where a number of fistulous openings led into the articulation, which was extensively destroyed by the disease. The sternal end of the clavicle was detached from the surrounding soft parts, and divided, with a metacarpal saw, about two inches from the articular surface. The section of the bone was made after inserting an elevator underneath. The articular surface on the sternal side was removed with chisel and sharp spoon. In another somewhat similar case the operation proved a failure, because the disease had already extended far underneath the sternum and the cartilages of the ribs on the same side. Resection of the sterno-clavicular joint was performed for the first time for caries (tuberculosis) by Wutzer in 1833, but as the disease extended later to the remaining portion of the bone he had to remove the entire bone subsequently. Velpeau removed the acromial end of the clavicle for caries in 1828, and this operation was repeated by Roux in 1834. Meyer removed the entire bone for rheumatic (?) caries in 1823.

Scapula.—Tuberculosis of the scapula is usually met with in patients suffering at the same time from tubercular affections of other bones. It occurs either as a superficial granulating lesion, producing superficial caries, or it gives rise to more extensive necrosis. The superficial lesions attack most frequently the spine and borders of the bone, while necrosis takes place more frequently if the disease is more centrally located. A number of cases have come under my observation where multiple fistulous openings led down to the external surface of the bone, at the bottom of which carious bone could be detected. Extensive incisions in the direction of the subcutaneous tracts always disclose a number of distinct superficial foci, which could be readily removed with the sharp spoon. A repetition of the scraping usually resulted in a final cure. Boeckel reports three operations on the scapula for tuberculosis. In one, a woman

40 years old, the entire scapula was removed, and the patient remained well six and a half years after the operation, and the arm was useful. In the remaining two cases partial resection was made, with favorable result and good use of the arm. In one case I resected the knee-joint, in a young woman, for long-standing osteo-arthritis, and the wound healed by primary union, and the patient enjoyed excellent health for a year and a half, when a rather acute inflammation of the shoulder-joint set in, with implication of the upper portion of the humerus. Resection of the shoulder-joint was made, but the wound never healed, and the disease in the shaft of the humerus extended. When I saw her again, two years after the first operation, she was emaciated to a skeleton. A number of fistulous openings led into the resected shoulder-joint and the diseased shaft of the humerus. The elbow-joint was also extensively diseased. The spine and outer surface of the scapula were the seat of extensive caries. At the urgent request of the patient, the scapula, clavicle, and arm were removed, and, although the patient did not lose more than half an ounce of blood during the operation, she never rallied from the immediate effects of the operation, and died twelve hours later.

Jäger (Ried, "Die Resectionen der Knochen," etc., p. 283. Nürnberg, 1847) resected almost the entire scapula for a tubercular affection in a girl 8 years old. The disease appeared after amputation of the arm for tuberculosis of the elbow-joint. Only the glenoid cavity and acromian process remained. The disease returned in this part of the bone and in other parts of the skeleton, and the child died nine months after the operation. Experience seems to show that when tuberculosis of the scapula presents itself as an isolated affection, in a patient otherwise healthy, a radical operation can be undertaken with a good prospect of success, even if the lesion is quite extensive; but that when the disease is complicated by similar affections in other bones or organs a radical operation is contra-indicated. Sinuses leading down to diseased bone should be freely laid

open and scraped, and the wound packed with iodoform gauze or sterilized gauze moistened with a 50-per-cent. emulsion of balsam of Peru, and suturing postponed until the entire surface of the wound is covered with vigorous granulations.

Sternum.—The primary starting-point of tuberculosis of the sternum is almost always in the interior of the bone. The upper portion, or manubrium, is the favorite seat for the disease in this bone. Not infrequently both sterno-clavicular joints are invaded later. The disease seldom leads to sequestration, but appears as caseous foci which often communicate with both surfaces of the bone. It attacks more frequently young adults than children. Partial resection of the sternum for caries was first done by Gallen. Moreau removed a portion of the sternum and the cartilages of two ribs, and Cittadini performed the operation for the same indication. Boyer removed more than one-third of the middle portion of the sternum, using the chisel and small saw and dividing the cartilage with a knife. It is reported that Genouville made a similar operation. Blandin resected two inches of the sternum with the cartilages of two ribs. Boeckel made partial resection of the sternum in two cases, in patients 12 and 18 years of age, and in both instances the operation proved a success. A very extensive resection of the sternum for tuberculosis was made by Bessel-Hagen. ("Ueber eine sehr ausgedehnte Resection des Manubrium Sterni wegen Caries." *Centralblat f. Chirurgie*, p. 902, No. 50, 1889.) Ohlendorf ("Ein Fall von Resectio Sterni." Dissertation. Würzburg, 1884) describes a case of resection of the sternum for tuberculosis of this bone. The patient was a woman, 38 years old, who was suffering from a swelling of the sternum for a year. On the left side, on a level with the third rib, was a fistulous opening which led between the cartilages of the second and third ribs, behind the sternum, into an abscess-cavity. The fistulous tract was laid open and the granulations scraped out. The symptoms, however, became aggravated and suppuration more profuse. The sternum and second and third ribs on left

side were exposed by dissecting up the skin in the shape of a flap. The cartilages of the exposed ribs and sternum, as far as its middle, were removed with the chisel and a large quantity of caseous pus escaped. The post-sternal abscess was now freely exposed and the fungous granulations were scraped out with a sharp spoon. The wound was closed with sutures and was nearly healed at the end of eight months, only a minute fistulous opening remaining. One of the most striking cases illustrating the benefits which are often derived by heroic measures in the treatment of tuberculosis was reported by Le Dentu to the French Congress of Tuberculosis. A man suffering from extensive tubercular lesions in the second stage, involving both lungs, was also the subject of extensive tubercular disease of the sternum. The general condition of the patient was so grave that the surgeon hesitated to perform the operation. As the patient requested urgently surgical interference, Le Dentu removed, November 14, 1886, nine centimetres of the sternum, together with two to three centimetres of the second, third, and fourth ribs on each side, and curetted the enormous tubercular abscess of the anterior mediastinum underneath the bones removed. The patient not only survived the operation, but the wound healed in six months, the pulmonary symptoms improved, and three years after the operation he enjoyed robust health. Removal of the manubrium of the sternum with sections of adjoining ribs can be done with safety if the bony parts to be removed are undermined by a tubercular abscess, as the thick abscess-membrane shuts out the anterior mediastinum, and if ordinary care is exercised no harm is inflicted on the important organs contained in this space.

In one case of tuberculosis of the sternum complicated by extensive tuberculosis of the costal cartilages on the left side, I found a large caseous focus near the centre of the body of the sternum. With chisel and spoon this focus was removed, leaving a defect at least an inch in diameter and involving the whole thickness of the bone; at the same time the costal cartilages from the

fourth to the seventh rib were resected. Recovery was speedy and so far (two years) has proved permanent.

Ribs.—Tuberculosis of the ribs is quite a frequent affection, and occurs in preference in persons whose general health is otherwise impaired. It appears either as a superficial granulating focus starting in the periosteum and reaching the subjacent bone by extension, or as a primary central osseous affection. Extensive undermining between the affected rib and pleura often takes place, giving rise to large peri-pleuritic tubercular abscesses. Tuberculosis of the ribs not infrequently results in the formation of a tubercular peri-pleuritic abscess in case the infection extends in the direction of the chest instead of the surface. The following case of this kind came under my observation recently. The patient was a young man without hereditary tendency to tuberculosis. During an attack of *la grippe* he was taken with pain in the left side, which was followed in a few months by the appearance of a swelling the size of a hen's egg. Local applications produced no effect, and the swelling gradually increased in size until the time I examined him, when it had attained the size of a large orange. With the appearance of the swelling the pain disappeared. The swelling was located in the mammary line, over the eighth and ninth ribs. Area of dullness extended beyond the base of the swelling. No indications of pulmonary disease. Patient somewhat anæmic and emaciated. Diagnosis: Tuberculosis of one or more ribs.

The abscess was opened by an incision parallel to the ninth rib and about eight ounces of typical tubercular pus was evacuated. Muscles around abscess-cavity pale and œdematous. From the floor of the abscess a fistula led to a point behind the cartilage of the ninth rib into a tubercular cavity. The same rib, on the inner surface to the extent of four inches, was denuded of periosteum and was carious. Four inches of the rib and its cartilage were excised, when another cavity as large as the external abscess was revealed, the floor of which was the pleura. Both abscess-cavities were thoroughly scraped out with a sharp

spoon, iodoformized and packed with iodoform gauze. In four weeks the patient left the hospital much improved in health and the wound completely healed. The disease is also very prone to extend to the costal cartilage, into which the tubercular granulations penetrate and which gradually remove the cartilage. Tuberculosis of the ribs is a painless affection, and patients suffering from it often only seek advice after the formation of a large tubercular abscess. Adults are attacked more frequently than children. It is a disease of adults. It is often in direct etiological relationship with pulmonary tuberculosis, which may originate from a tubercular focus underneath a rib, or pulmonary tuberculosis may become the cause of the periostitic form of rib tuberculosis. The process may start in the perichondrium, especially in children. I have already alluded to this subject, and cited instances in the chapter on tubercular chondritis. When the disease primarily affects the cartilage, it starts in the perichondrium and extends from here to the cartilage. In all specimens of this kind I have noticed that the greatest defect answers to the service of the cartilage. Later, extension of the disease along the periosteum leads finally to the bony part of the rib. In the following case the disease remained limited to the cartilaginous structure. The patient was a man 46 years old, and well nourished. After an attack of typhoid fever, eight months ago, he experienced an intermitting pain in the left side at a point corresponding with the seventh and eighth ribs, which radiated in the direction of the spine. A month later a swelling formed at that point near the sternum, which gradually increased in size until he was admitted into the Milwaukee Hospital for surgical treatment. The swelling at this time covered an area about four inches in diameter. Fluctuations could be distinctly felt; base of swelling surrounded by a ring of indurated tissue. No rise in temperature. Diagnosis: Tuberculosis of rib. Operation February 6, 1890. An oval skin-flap was made with the convexity directed downward, which freely uncovered the muscular tissue. After opening of the abscess two fistulous tracts

could be followed leading between and behind the cartilages of the seventh and eighth ribs. The under surface of both cartilages was much eroded, perichondrium thickened. Both cartilages and adjacent portion of ribs were removed and the abscess-cavity thoroughly scraped out and iodoformized. The wound was sutured and a capillary drain of catgut introduced. Primary union throughout. No relapse. General health improved. The tubercular affection extends along the same rib, or a number of ribs are affected simultaneously or in rapid succession. The resulting abscess spreads either toward the skin or pleura, and sometimes the abscess appears *a distance* from its starting-point. Scraping operations, as a rule, prove unsuccessful in these cases, even when the disease has a periosteal origin, as the tubercular granulations are usually more copious underneath than on the outer surface of the rib. If the disease, before an abscess has formed and opened, does not yield to injections of iodoform or balsam of Peru, rib resection is indicated. The frequent relapses which have followed this operation are due to incomplete removal of tubercular tissue. The fistulous tracts are often very small and difficult to follow. It is necessary in nearly every case to resect the entire diameter of the rib and to remove a sufficiently long section to completely expose the para-periosteal granulations or abscess. The scraping must be done with a large, sharp spoon and continued until perfectly healthy tissue is reached. If more than one rib is affected, multiple resection becomes necessary.

Tillmanns ("Resektion der vorderen linken Thoraxwand und zwar der Rippen u. der Weichtheile wegen schwerer Tuberculose," etc. *Bericht der Med. Gesellschaft in Leipzig*) resected the anterior wall of the thorax on the left side, including the ribs and soft parts, for extensive tuberculosis, exposing completely the left pleural cavity, which was filled with tubercular pus. The surface was later covered with large skin grafts, and the patient made a satisfactory recovery. The section of a rib can be done quickly and safely with a strong pair of bone

forceps. Iodoform-gauze tamponade or a dressing saturated with balsam of Peru should be employed after the operation and the suturing of the wound postponed until the wound throughout is covered with healthy granulations. Partial resection of ribs for caries appears to have been a well-known procedure for a long time, as Celsus alludes to it in describing this affection. Galen is credited with having performed the operation. Fabricius ab Aquapendente declared the operation as impracticable. Aymar, Severinus, and, later, Gooch and Oleweltt revived the operation. During the early part of the present century it was practiced by Percy, Richerand, Cittadini, Roux, Velpeau, Anthony, Clot, Fricke, Warren, Dixon, Karawajew, Spessa, Jaquet, and Textor. McDowell resected, in 1828, the posterior portion of the sixth and seventh ribs, disarticulating them from the vertebral column.

Extirpation of a complete rib was first done by Fiori. Cittadini, Anthony, and Velpeau used bone forceps for making the bone section.

CHAPTER XXXIV.

Tuberculosis of Joints of Upper Extremity.

Shoulder-Joint.—Of all the large joints the shoulder-joint is least frequently the seat of tuberculosis. The disease, as a rule, originates in the head of the humerus, osseous foci in the scapular part of the joint being exceedingly rare. *Caries sicca* is found most frequently in this joint. This form of joint tuberculosis gradually destroys the head of the humerus without the formation of an abscess, and the joint, instead of being swollen, is often diminished in size from the destruction of the head of the bone and contraction of the capsular ligament.

The appearance of the upper extremity of the humerus is well shown in the illustration on page 398.

The transverse section of the humerus below the tuberosities shows the concentric atrophy of the shaft which attends this form of tuberculosis, and which was first described by Volkmann. The disease is met with in young persons with and without tuberculosis of other organs. The exciting cause can often be traced to a trauma. The so-called *caries carnosa* (König) also occurs in this joint, and consists in an extension of the tubercular process from the joint into the medullary cavity of the shaft. The medullary tissue is replaced by fleshy granulations, through which tubercles are disseminated.

The early detection of effusion into the shoulder-joint is difficult owing to the tense capsular ligament, dense fascia, and deep muscular layers which cover the joint. A swelling under the deltoid muscle more frequently suggests an affection of the subdeltoid bursa, or an inflammatory exudation into the loose connective tissue underneath the muscle than distension of the capsule of the joint. Perforation of the capsule often takes place at a point where it is not covered by muscles, which is the case at the lower border of the subscapular muscle, in which event the abscess presents itself in the axilla. At other times

the contents of the joint escape at a point where the tendon of the biceps passes over the joint, when the abscess appears under the deltoid muscle. More frequently, however, the abscess migrates farther and presents itself in the intermuscular septa

FIG. 54.—CARIES SICCA OF SHOULDER-JOINT. (*Volkmann.*)

a, *b*, *c*, different stages of destruction of head of humerus; the lines mark the size of the normal head of humerus. *K*, the remnant of the head of the humerus.

of the arm, or in the direction of the scapula, or in the fossa subscapularis, supra- or infra- spinati, or underneath the pectoralis major. Iodoform injections are most useful in the synovial form of tuberculosis of the shoulder-joint. If this method of treatment is resorted to in caries sicca, it is necessary to com-

bine with the intra-articular, parenchymatous injections, as the capsule of the affected joint is always thickened. Caries sicca, under favorable circumstances, undergoes a spontaneous cure in from two to three years, the result being a stiff joint, but useful limb. In three cases of caries sicca, in which König made resection of the shoulder-joint, the operation was followed by acute miliary tuberculosis. If the disease involves at the same time any considerable portion of the shaft of the humerus, amputation through the shoulder-joint offers the only prospect of eradicating the disease *in toto*. In operations of this kind the glenoid cavity should be removed completely by dividing with the saw the neck of the scapula, as in many cases of amputation through the shoulder-joint for tuberculosis the disease returned in the scapula, and in some of these cases, at least, the local recurrence was undoubtedly due to incomplete removal of diseased tissue on the scapular side.

Resection of Shoulder-Joint.—This operation is indicated in the treatment of tubercular affections of the shoulder-joint that resist intra-articular and parenchymatous injections of iodoform or balsam of Peru, and when the patient does not suffer at the same time from general tuberculosis or tuberculosis of other organs not amenable to successful surgical treatment.

History of Operation.—Boucher removed parts of the shoulder-joint for gunshot wounds in 1753, and Thomas opened the joint for the extraction of necrosed bone in 1740. The first authenticated case of intentional resection of the shoulder-joint for disease was done by Ch. White ("Cases in Surgery," vol. i) in 1768. The patient was a boy, 14 years of age, who was the subject of an acute suppurative inflammation of the shoulder-joint, terminating in the formation of an extensive abscess, which had discharged itself externally. The operation is described as follows: "I began my incision at that orifice which was situated just below the processus acromion, and carried it down to the middle of the humerus, by which all the subjacent bone was brought into view · then took hold of the

patient's elbow and easily forced the upper head of the humerus out of its socket, and brought it so entirely out of the wound that I readily grasped the whole head in my left hand and held it there till I had sawn it off with a common amputation saw, having first applied a paste-board card betwixt the bone and the skin. I had taken the precaution of placing an assistant, on whom I could depend, with a compress just above the clavicle, to stop the circulation in the artery if I should have the misfortune to cut or lacerate it; but no accident of any kind happened, and the patient did not lose more than two ounces of blood, only a small artery which partly surrounds the joint being wounded, which was easily secured." The patient made a good recovery, and four months later left the infirmary completely cured, the functional result being excellent. Sequestration of the sawn surface of the humerus delayed the healing of the wound. Mr. White's example was followed by Mr. Bent, of Newcastle, and Mr. Orred, of Cluster. It appears, from the accounts we have of these operations, that the disease for which they were performed was really caries of the shoulder, and that the patients retained limbs which, if not perfect, were at least extremely useful. Notwithstanding this encouragement to extend the practice, it seems to have been afterward treated in England with entire neglect. In France, Moreau the elder performed the operation successfully in 1786, and the army surgeons, particularly Banus, Percy, and Larrey, frequently resorted to it on account of recent gunshot wounds instead of removing the limb. In Scotland the operation was revived by Mr. Syme in 1820, and was later performed by Babington, Liston, Baddely, Fergusson, Lawrence, Hunt, Coote, Hutchinson, Erichson, Birkett, Stubbs, Blackmann, and others. In Germany the first resection of the shoulder was made by Lentin in 1771, and he was followed by Wutzer, Fricke, Jäger, Blasius, Textor, Dietz, Heyfelder, Langenbeck, Esmarch, Wilms, and Bartels. Symes says ("Treatise on the Excision of Diseased Joints," p. 40, 1831): "There is no case in which ex-

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cision is so decidedly preferable to amputation as caries of the shoulder-joint. The diseased bone can here be readily cut away without injury to any important organ, and the object gained is no less than the preservation of the whole superior extremity."

Incision.—White removed the head of the humerus through a straight incision from the acromion process downward through the centre of the deltoid muscle. The same incision was practiced by Virgarrus. The incisions of Larrey, Kern, Chassaignac, and Jäger are only slight modifications of White's incision. Baudens commenced his incision just below the coracoid process of the scapula and carried the knife along the groove between the pectoralis major and deltoid muscles to the groove for the biceps muscle. If this incision did not afford the necessary room for the removal of the diseased head of the humerus, he enlarged the wound by making two small transverse cuts (but only through the muscles) in a forward direction at each end of the vertical incision. Baudens' incision was modified by Langenbeck, Malgaigne, and Robert.

Frank and Ried joined the upper end of the vertical incision by a short transverse cut extending beneath the acromion process. Langenbeck made a transverse incision which crossed the vertical at the upper end at each side, making thus a **T** incision. Bouzairies joined two oblique incisions in the figure of the letter **V**, making a flap with the base directed upward.

Bent made a long incision from the joint downward in the furrow between the pectoralis major and deltoid muscles; and, as this did not afford enough room, he made two short transverse cuts, the one meeting the upper end of the long cut dividing the clavicular attachment of the deltoid muscle, the lower the humeral insertion of the pectoralis major, making thus a quadrangular flap with the base directed toward the body.

Bell, Morel, and Guepratte made a semilunar incision with the base directed upward. Wattmann carried the knife from the posterior margin of the acromion process along the border of the deltoid to its insertion, and joined it by another incision

extending from the tip of the coracoid process to the same point, making in this way a triangular flap which included the deltoid muscle.

Sabatier's flap incisions are the same, only the space included by the incision is smaller. The older Moreau made a quadrangular flap with the base directed downward, while a similar flap, with the base in an opposite direction, was advised by Manne, Percy, the younger Moreau, Textor, and Jäger.

Syme (*loc. cit.*, p. 50) made a perpendicular incision from the acromion through the middle of the deltoid, nearly to its attachment, and then another one upward and backward, from the lower extremity of the former, so as to divide the external part of the muscle. "The flap thus formed being dissected off, the joint will be brought into view, and the capsular ligament, if still remaining, having been divided, the finger of the surgeon may be passed around the head of the bone so as to feel the attachments of the spinati and scapular muscles, which can then be readily divided by introducing the scalpel first on the one side and then on the other. After this, the elbow being pulled across the fore part of the chest, the head of the humerus will be protruded, and may then be easily sawn off while grasped in the operator's left hand." Syme described one of his operations of resection of the shoulder-joint in which the whole operation, including the dressing, occupied only ten minutes.

Albanese (Virchow u. Hirsch's "Jahresbericht," 1871, B. ii, p. 402) makes a posterior incision in the shape of an inverted **L**, commencing at the spine of the scapula, at the junction of this with the acromion process, extending from above downward and forward to the head of the humerus, from where it is directed forward, terminating at the tuberculum majus. The muscles are separated with the periosteum, and through the wound the head of the humerus is removed. It is claimed that this incision has the advantage over other posterior incisions, as it does not endanger the circumflex nerve.

Modern Operation.—The incisions that are now practiced

in resection of the shoulder-joint are such that will secure free access to the diseased structures without injuring any of the muscles or other important para-articular structures. Resection for tubercular affections of the joint requires not only an incision through which the head of the humerus can be dislocated and removed, but it must be made in such a locality and in such a manner as to enable the operator to remove the diseased capsule and para-articular tissues and as much as necessary of the scapular portion of the joint. Incision through the centre of the deltoid, detachment of important muscles, or transverse incision through them is strenuously avoided, in order to secure a satisfactory functional result by the operation. A straight anterior or posterior incision is now generally selected for typical or atypical resection and arthrectomy.

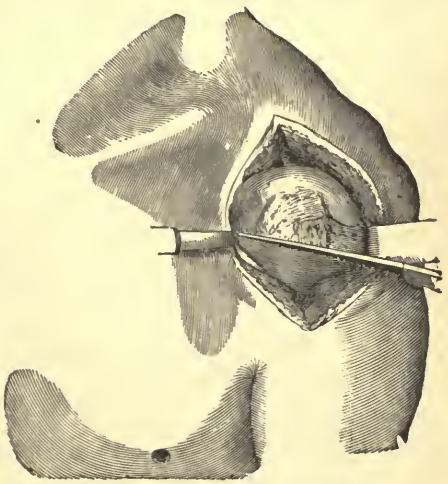

FIG. 55.—RESECTION OF SHOULDER-JOINT. STRAIGHT ANTERIOR INCISION.

The anterior incision is commenced at a point half way between the acromial end of the clavicle and the coracoid process, and is carried directly downward six to ten centimetres, dividing all the tissues down to the joint. The margins of the wound are now retracted, the long head of the biceps tendon held out of the way, and the anterior surface of the joint fully exposed. The capsule is opened by making three incisions, which, when united, give the appearance of a narrow horseshoe: Ω. The first vertical cut is made while the arm is rotated outward through the inner half of the capsule, when the tendon of the subscapular muscle is attached. The arm is then rotated inward and the second vertical incision made through the capsule and down to the tendons of the supra-

spinatus, infra-spinatus, and teres minor muscles; these two incisions are then united by a transverse cut through the upper portion of the capsule. Through this opening the head of the humerus can be readily dislocated, and, after separation of the posterior portion of the capsular ligament, the diseased part of the bone is removed by sawing off the head through the surgical or anatomical neck, or by removing foci with chisel and sharp spoon. The latter procedure is especially to be recommended in performing this operation on children, as the removal of the upper epiphysis in such cases would be very likely to result in great shortening and very imperfect restoration of function. In children atypical resection of the shoulder-joint should always be done if, by this operation, all diseased tissues can be reached and removed. After removal of all osseous foci the diseased capsule is extirpated and the glenoid cavity carefully examined and thoroughly dealt with. If the wound is packed with iodoform gauze and closed later by secondary suturing, a posterior counter-opening for drainage is unnecessary. The tendon of the biceps muscle and the circumflex nerve must be carefully protected against injury, which can only be done by making free use of an elevator or other blunt instrument in isolating and dislocating the head of the humerus. Resection of the upper end of the humerus, within the limits of the surgical neck, can be done most advantageously through a posterior incision. The incision, six to eight centimetres in length, should start from the posterior border of the acromion process, downward through the posterior portion of the deltoid, directly down to the joint. If the arm is kept rotated outward the incision falls in line with the centre of the great tuberosity of the humerus. The muscles and periosteum are separated from the bone while the arm is being rotated outward. In this way the other side of the bicipital groove is reached, when the tendon of the subscapular muscle is detached. The arm is then rotated more and more inward, when the muscles inserted posteriorly are separated with the periosteum and the capsular ligament.

Finally the arm is brought forward and the head of the humerus dislocated backward and partially or completely removed. After the removal of all osseous foci the capsule and glenoid cavity are dealt with in the same manner as in making the anterior incision. Arthrectomy and atypical resection of the shoulder-joint could be done most readily and with the least degree of violence to the soft parts surrounding the joint by temporary resection of the acromion process, combined with a straight anterior or posterior incision. After removal of all diseased tissue the acromion process could be sutured in its normal location with catgut or silver-wire sutures. This operation will, undoubtedly, be more perfected and will be frequently resorted to in the future, in proper cases. In the after-treatment of resection of the shoulder-joint the arm should be well supported and immobilized in such a manner that the upper end of the humerus is brought in close contact with the glenoid cavity or sawn surface of the neck of the scapula. This object can be attained to the greatest degree of perfection by padding arm and forearm with absorbent cotton and bringing the forearm across the chest, slightly elevated, and encircling the whole limb, chest, and the top of the opposite shoulder in a light plaster-of-Paris dressing. Passive motion should not be made until the wound has healed and a sufficient time has elapsed for the formation of a new joint, which will require from four to six weeks. Active use of the

FIG. 56.—EXCISION OF SHOULDER-JOINT AND UPPER THIRD OF HUMERUS. RESULT TWENTY-FIVE YEARS AFTER OPERATION. (*Annals of Surgery.*)

arm is postponed still longer. It is not often that patients can raise the arm above the horizontal position, even when the functional result is excellent. Langenbeck reported a case of excision of the entire shaft of the humerus, with both articular ends, in which almost complete reproduction of the bone took place, with good use of the arm. If several inches of the bone have to be removed, and reproduction of bone does not take place, the arm can be made useful by the use of a proper apparatus.

The muscular atrophy, which is often present to a marked degree, is to be treated by massage and the use of the interrupted current.

Elbow-Joint.—Like in the shoulder-joint, tuberculosis of the elbow-joint is essentially a disease of young adults, and attacks much more frequently primarily the bones than the synovial membrane. In frequency the osseous form appears first in the olecranon, where it is often met with in the form of a wedge-shaped, necrotic infarct; then the lower end of the humerus, the head of the radius being affected only in exceptional cases. König found, in 62 resection specimens of this joint, that the disease was purely synovial in 10 and osseous in 42; of these 42 cases the ulna, more especially the olecranon, was the primary seat in 22, the humerus in 17, the humerus and radius together in 21, and the radius in one. Middeldorpf found, in 137 cases, that the disease was primarily synovial in 30 and osseous in 107. Of the bones the ulna, chiefly the olecranon, was the seat primarily in 49, the humerus in 33, the external condyle in 4, the humerus and ulna together in 18, the radius in 3, all of the bones in 2, and the radius and ulna in 2. Primary synovial tuberculosis was more frequent in persons less than 14 years of age than afterward, the proportion between synovial and bone disease in childhood being as 29.5 to 70.5. Middeldorpf ("Weitere Beiträge zur Resektion des Ellenbogen Gelenkes." *Archiv f. klin. Chirurgie*, B. xxxiii, p. 226) is of the opinion, from a clinical study of a large number of cases of tuberculosis

of the elbow-joint, that resection is indicated in about 73 per cent. In his cases the right arm was affected in 57, the left in 38, and both sides in 53. Fifty-three were males and 46 females. The largest number of cases were between 20 and 25 years old.

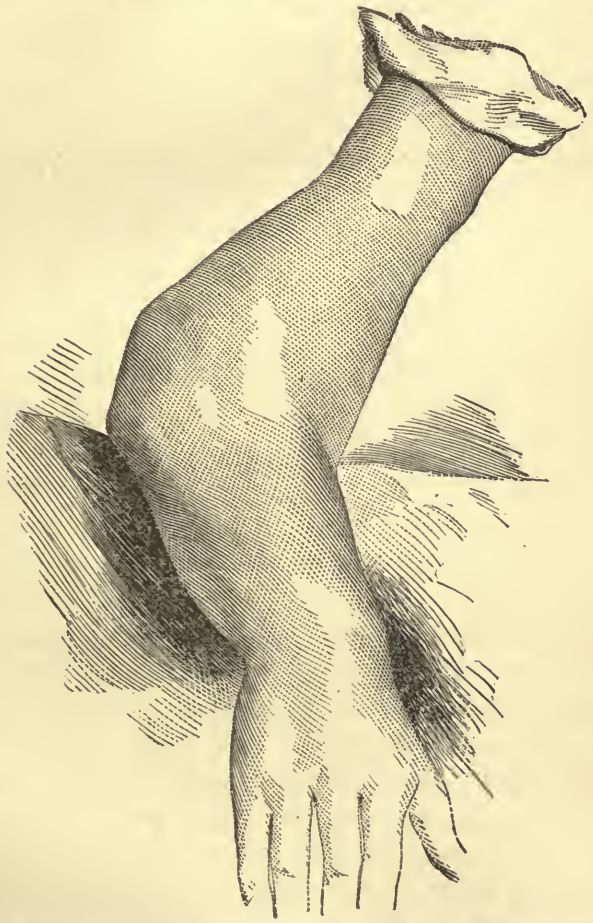

FIG. 57.—TUBERCULOSIS OF THE ELBOW-JOINT, WITH MARKED ATROPHY OF MUSCLE OF ARM AND FOREARM.

The synovial form was represented by about 25 per cent. In nearly 75 per cent. osseous foci were found in both articular extremities.

One of the first symptoms which points to the existence

of tuberculosis in this joint is limited motion. The patient holds the arm in a flexed position, and is unable to extend it completely; at the same time the forearm gradually assumes a fixed, pronated position, rotation of the forearm being either entirely absent or always limited. The swelling, which at first is not well marked, appears first over the radio-humeral joint and along the sides of the olecranon, in localities where the joint is nearest to the surface. When the swelling has become extensive it assumes a spindle-shaped form, the centre of which corresponds to the joint, from which it tapers gradually toward the arm and forearm. This peculiar shape of the arm becomes more marked after muscular atrophy is far advanced.

Perforation of the capsule and the formation of para-articular abscesses occur most frequently in the same regions; but the abscesses often wander quite a distance before spontaneous perforation takes place, so that it is often difficult, if not impossible, to follow the fistulous tracts with a probe into the joint. Intra-articular injections of iodoform can be made by entering the joint from the outer aspect, between the head of the radius and the external condyle of the humerus. As this conservative treatment is often followed by stiffness or false or even bony ankylosis, the forearm should be kept in the most favorable position during the treatment, in the event that, if such results follow, the limb will be most serviceable to the patient. This position is flexion of the forearm at a right angle with the arm, with the forearm half way between pronation and supination.

Resection and Arthrectomy. History of Operations.—The first attempts to substitute resection of the elbow for amputation were made by Bilguer, who extracted fragments of bone in a compound fracture of this joint; and Wainmann and Görke, who made partial resections, the former for compound dislocation, the latter for gunshot wound. The original idea of this operation proceeded from Mr. Park, of Liverpool, who made the resection on the dead subject, but, for what reason does not appear, he never applied it in practice. Park made the opera-

tion on the cadaver and recommended its adoption in practice. The elder Moreau made the first complete resection of the elbow-joint in 1794. Percy, Dupuytren, and Roux followed his example when the operation was forgotten in France, until it was revived by Chassaignac and Maisonneuve, in 1850. The two Moreaus, however, adopted it in good earnest, and employed it at Bar-sur-Ornain with great success. Three of their cases are detailed in the treatise of Moreau junior, and two others are simply mentioned by him in which the result was equally satisfactory, but, the patients being young ladies, the particulars are not related. In England it was introduced by Park and Syme. In Germany the first complete resections of the elbow-joint were performed by Jäger and Textor. In Italy the operation was introduced by Mazzoza. In Russia, by Pirogoff, Hübbenet, Nemert, and the two Heyfelders. In America, by Smith, Bauer, and Carnochan.

Incision.—Park made a single, straight, posterior incision, the same as was later practiced by Chassaignac and Langenbeck. The modifications of this incision have been various; thus, the H after J. F. Heyfelder and Maisonneuve, the + after Park, Lizars, and Syme; the I after Simon; the T after Thore, Liston, and Roux; the double longitudinal incision after Jeffray. Textor formed a posterior triangular flap with the base directed downward, while Guepratte made an oval flap with the base in an opposite direction. Moreau and Dietz preferred a single, or, if this did not afford enough room, a double H quadrangular flap.

Modern Operation.—The most serviceable incision is the straight posterior made directly over the centre of the olecranon process, and if this does not afford ample room and access to every part of the joint it can be joined by a short, straight, transverse incision directly over the radio-humeral joint.

If the articular ends of all of the three bones which enter into the formation of this joint are to be removed, the muscular attachments, with the periosteum are to be separated, and by forcible flexion of the arm the ends are rendered accessible and

are sawn off. The tendon of the triceps muscle is to be sutured to the upper end of the ulna after the resection has been completed, and the arm is dressed for at least three weeks in the extended position. In liberating the lower end of the humerus extreme care must be exercised in protecting the ulnar nerve against injury. This is best done by lifting it out of its groove behind the internal condyle of the humerus with the periosteum with an elevator, and keeping it out of the way by a blunt

FIG. 58.—LANGENBECK'S INCISION. (*Bryant.*)

FIG. 59.—LISTON'S INCISION. (*Bryant.*)

retractor, as advised by Langenbeck in the description of his subperiosteal resection of this joint.

Complete resection of the elbow-joint is seldom required, and the chisel is gradually taking the place of the saw in excision of this joint, which, in the majority of cases, should not be complete, but partial.

Temporary Resection of Olecranon.—Partial resection of the elbow-joint, after temporary resection of the olecranon, can be done through a straight posterior incision to which, if need be, short, transverse cuts can be added directly over the joint to answer special indications. The limb should always be rendered

bloodless by elastic constriction, which should be applied at a point where the musculo-spiral nerve is well protected by muscles. Vogt not only preserved the olecranon, but also the epicondyles in resection of the elbow-joint.

Of the many cases of resection of the elbow-joint done by myself, the following have been selected to illustrate the different forms of tuberculosis of this joint, as well as for the purpose of showing what may be expected from this operation, if an attempt is made to preserve the olecranon process.

Case I. Man aged 48, German, tailor by occupation. Duration of disease about one year. Joint swollen, a number of fistulous openings communicating with it. An attack of acute para-articular inflammation commenced two weeks ago, but is now subsiding. Operation May 18, 1890. Straight posterior incision. Complete chisel resection of joint after temporary resection of olecranon process. The articular surface of the ulna contained a triangular sequestrum projecting into the joint. After removal of the sequestrum the cavity was thoroughly scraped out, and, after disinfection and iodoformization, the wound was sutured and drained with a catgut drain. Olecranon fastened with two aseptic ivory nails. Arm dressed in extended position. Patient left hospital May 25th, only a very small sinus remaining. I was informed later that the wound healed and a fair degree of motion of joint was recovered, but then symptoms of pulmonary tuberculosis developed and death resulted from this cause a year later.

Case II. Woman 48 years old, with disease of right elbow-joint of four years' duration. An abscess communicating with the joint opened three months ago, leaving a permanent fistula. Operation May 31, 1889. Same incision. Disease limited to synovial membrane, capsule, and articular surfaces of joint. Complete chisel resection of joint, with preservation of olecranon process. Fixation of olecranon process with two chromicized catgut sutures. Primary healing of entire wound. Fair motion of joint, and after six months good use of arm. No local

recurrence, and marked improvement of general health of patient.

Case III. Male 18 years old, with tubercular family history, the subject of primary synovial tuberculosis of elbow-joint for nine months, was subjected to resection December 3, 1889. Temporary resection of olecranon process. Extensive synovial disease, with implication of articular cartilages. Atypical resection of articular ends. Catgut drain. Primary union of wound. At the end of four months useful arm and about half the normal range of motion. No local recurrence to date.

Case IV. Tailor, aged 44, without any hereditary tendency to tuberculosis, has been suffering with an affection of the right elbow-joint for five years, which recently has prevented him from following his occupation. Joint greatly swollen, presenting all the typical appearances of tuberculosis. Posterior straight incision and typical chisel resection of joint, with preservation of olecranon. A number of rice-bodies were found in the joint, with great thickening of synovial membrane and capsule. The soft joint-structures were thoroughly extirpated. Olecranon nailed to shaft of ulna. Primary union of wound. At the end of three months patient was able to resume his occupation, having nearly the normal range of motion. No local recurrence, and general health greatly improved.

Bruns recommended osteoplastic resection of the elbow-joint in 1858. Mosetig-Moorhof ("Ueber osteoplastische Resection des Ellenbogengelenkes." *Wiener Med. Presse*, pp. 825, 857, 1883) revived Bruns' operation, and reports three successful cases. The olecranon process, if not the seat of the disease, is sawn through at its junction with the shaft of the ulna, and, after resection of the joint, is fastened in its normal place with a bone suture of chromicized catgut.

Trendelenburg ("Ueber die temporäre Resection des Olecranon," etc. *Centralblatt f. Chirurgie*, No. 52, 1880) made the first temporary resection of the olecranon in March, 1878. He exposes the process by a flap, the convexity of which is

directed upward. The olecranon is divided at its junction with the shaft of the ulna with a chisel, and is again fastened in its place with two metallic (steel wire) sutures after the completion of the operation on the joint. He places great stress on the importance of making the external incision in such a manner that it does not correspond with the incision through the bone and into the joint, so that, after suturing of the external wound, the deep incisions are to a certain degree subcutaneous injuries.

Spuhn ("Ueber die Resection des Ellenbogengelenks." Dissertation, Bonn, 1885) reports eighteen cases of resection of the elbow-joint from the clinic at Bonn, of which twelve were made for tubercular disease and six for old dislocations and fractures. The method employed is the following: A transverse curved incision is made over the posterior aspect of the joint from one condyle to the other, with the base directed upward. The short flap thus made is dissected away from the fascia of the triceps muscle and the olecranon process. With dull instruments the olecranon process is isolated from the soft parts with exclusion of the periosteum. After careful isolation of the ulnar nerve with the attached soft parts, the joint is incised along the inner side of the olecranon, and the process divided transversely with a broad, sharp chisel. This exposes the joint freely, and through the wound the articular ends of the bones can be removed and the capsule extirpated. After the resection the olecranon process is fixed to the shaft of the ulna in its former position by means of a silver- or iron- wire suture, and, after disinfection of the wound, is sutured and carefully drained, and the limb immobilized in a paste-board splint. The functional results were excellent.

Pick (London *Lancet*, October 2, 1886) described an osteoplastic resection of the elbow-joint in which the healthy olecranon process was cut off with a sharp chisel and the joint thus opened. After removal of the diseased portion of the joint the tip of the olecranon process was united by a strong wire suture to the sawn surface of the ulna. The wire was left in and

patient made a good recovery, and the functional result was satisfactory.

Plachte ("Beitrag zur doppelseitigen Ellbogen-resection." Dissertation. Würzburg, 1885) has collected twenty cases of double resection of the elbow-joint, two of which occurred in the klinik in Würzburg. The indications were: tubercular disease, thirteen times; chronic rheumatism, four times; inveterate

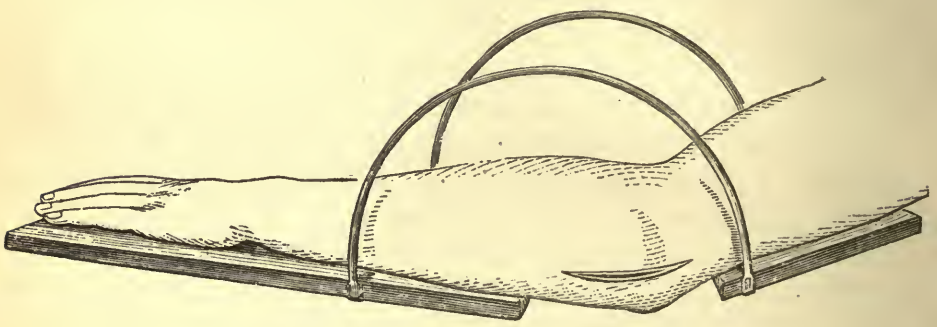

FIG. 60.—BRACKETED DOUBLE SPLINT. (*Esmarch.*)

dislocations, two times; ankylosis after small-pox, once. Only one of the cases terminated fatally. In most cases a fair mobility, and, in some of them, almost normal function of the joint was obtained. Ankylosis followed on one side in two of the

FIG. 61.—WOODEN SPLINT WITH OPENING FOR INTERNAL CONDYLE. (*Stromeyer.*)

cases. In eleven cases the operations were made from one to ten years apart. At the same time in three cases, and in six cases no reference is made in regard to the time of the operations.

Fixation of the olecranon after temporary resection of this process can be secured by two durable catgut sutures. I have employed this method of fixation in a number of cases, and always obtained bony union and an excellent functional result.

The arm must be kept supported in the extended position by a well-padded anterior splint, or in a plaster-of-Paris case, until bony union has taken place, which will require, according to the age of the patient, from three to six weeks.

Figs. 60, 61, 62, and 63 represent some of the splints which

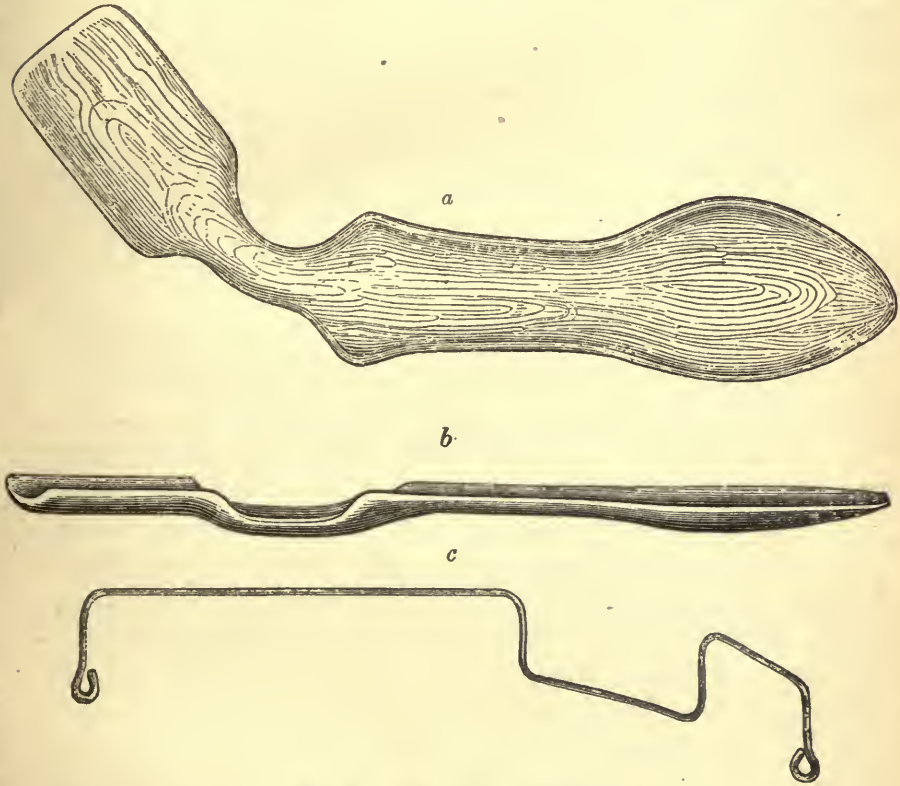

FIG. 62.—CURVED WOODEN SPLINT.
a, upper surface; *b*, lateral view; *c*, wire for suspension.

have been recommended and used in the after-treatment of resection of the elbow-joint.

After this time (three to six weeks) the forearm is flexed gradually from day to day until it can be flexed at right angles with the arm. Passive and active motion are to be carefully but persistently practiced after this time. The forearm, after resection of the elbow, partial and complete, manifests a strong

tendency to fall in a position of pronation,—an occurrence which can only be avoided by the employment of carefully prophylactic mechanical measures to maintain the limb in a desirable position.

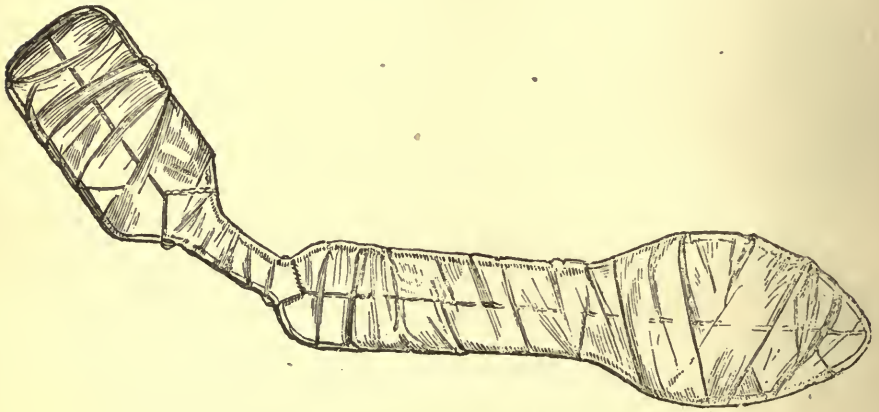

FIG. 63.—WIRE SPLINT INCASED BY PLASTER-OF-PARIS BANDAGE.

Results.—The functional results after arthrectomy and resection of the elbow-joint for injury or disease are better than after similar operations upon any other of the larger joints. After chisel resection of the joint I have repeatedly obtained almost the normal range of flexion and extension and a fair degree of rotation of the forearm. The strength and utility of the resected limb, as a rule, compares favorably with the opposite arm. The immediate results of the operation are not equally satisfactory. In twelve resections of the elbow-joint made by Boeckel, eleven survived the operation and one died, the immediate cause of death being acute tuberculosis, which developed soon after the operation. Of three that recovered from the operation one died (child), nine months later, of tubercular meningitis; one (adult), after a year, of pulmonary tuberculosis, and one (child) of diffuse miliary tuberculosis. Of the eight definitely cured, in one the elbow was ankylosed at right angles, and in another the same condition with the arm in a higher degree of flexion; the remaining five (children from 6 to

13 years, except one) recovered perfect use of the arm. Deaths from pulmonary tuberculosis after this operation will be less frequent in the future, when surgeons will more generally recognize the importance of early operations, and will be more careful in removing all osseous foci and infected soft tissues.

Wrist-Joint.—The wrist-joint is quite frequently the seat of tuberculosis. In this joint the synovial form predominates. I have met with it most frequently in adults, and in several cases the patients were from 50 to 60 years of age. Tuberculosis of the numerous tendon-sheaths surrounding this joint holds often a direct relationship to the disease within the joint, as a primary tubercular tendo-vaginalis not infrequently invades the joint, and, *vice versâ*, primary tuberculosis of the joint is very prone to involve, at a comparatively early stage, the tendon-sheaths. From a diagnostic point little is to be said, as the external appearances of a tubercular wrist-joint are so characteristic and typical that a diagnosis in an advanced case can be made almost upon first sight. In advanced cases the joint is uniformly swollen and the hand is held in a flexed position. Marked atrophy of the muscles of the forearm is a conspicuous and almost constant symptom. Mono-articular chronic inflammation of the wrist-joint, with absence of any acute signs or symptoms, is almost safe to call tubercular in its origin, course, and consequences. As the disease, as a rule, is not limited, but involves the synovial membrane and ligamentous structures of all the bones which enter into the formation of this joint, the treatment must apply to all of these structures. Intra-articular and parenchymatous injections of iodoform emulsion, which have yielded very satisfactory results in tubercular affections of this joint, must be made in such a manner as to bring the antibacillary mixture in contact with every portion of the joint. As the carpal bones are, almost without exception, very much softened, they can be penetrated with a small trocar without difficulty, and by doing so different portions of the joint are reached at the same time, and the injection becomes parenchy-

matous as well as intra-articular. The joint can be entered very readily on the ulnar side just below the styloid process, from where the trocar is pushed forward until its point reaches the radial side, when the injection is made at intervals as the cannula is withdrawn. In repeating the operation the injection can be made from the dorsal side at different points, in order to reach parts inaccessible to the transverse puncture. For the purpose of preventing flexion of the hand a well-fitting and carefully-padded anterior splint should be applied, reaching from the base of the fingers to the bend of the elbow with the hand in a slightly-extended position. Iodoform injections should be given a fair trial before deciding upon excision of this joint, as, in case the treatment proves successful, the functional result is much more satisfactory than after operative interference.

RESECTION OF WRIST-JOINT.

History of Operation.—The first resection of the wrist-joint was made by Beyer in 1762, but in this case the operation was made for an injury caused by a fragment of a shell. Result good. In 1839 Dietz made the first resection of this joint for disease (caries.) The disease returned, and four years later the forearm was amputated. In England the operation was performed by Fergusson in 1851, and the following year Maisonneuve reported the first case from France. Simon performed the operation during the same year, Erichsen in 1853, Butcher in 1855, Farn in 1856, Scymanowsky in 1857, and Bickersteth in 1859.

Incision.—Maisonneuve resorted to a straight dorsal incision. Chassaignac made a similar incision on the ulnar side of the joint.

Doublet advised two straight incisions,—one on the ulnar and the other on the radial side of the joint. The same method has more recently been advocated by Adelmann and Sprengler. Simon preferred two straight incisions,—one over the dorsal, the other over the palmar aspect of the joint. Roux modified

Doublet's method by adding two small transverse incisions at the lower end of the straight cuts, so that the incisions represented two Ls with the transverse bars directed toward the dorsum. Two quadrangular flaps, formed by extending the two transverse incisions of Roux, represent the operation as

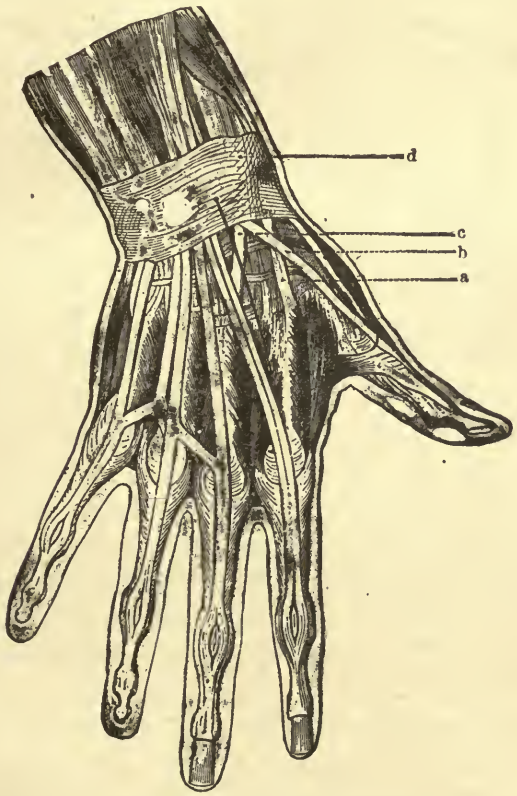

FIG. 64.—LANGENBECK'S INCISION.

a, extensor carpi radialis longior; b, extensor longus pollicis; c, extensor carpi radialis brevior; d, posterior annular ligament.

practiced by Dürr and Erichsen. Fergusson's method consists in uniting the two incisions of Doublet by a transverse cut about an inch above the joint.

Velpeau made a quadrangular flap with the base directed toward the hand.

Guepratte and Butcher recommended a semilunar dorsal flap with base directed upward. In all these flap operations the incision was carried only down to, but not through, the extensor tendons, which, during the further steps of the operation, were to be kept out of the way by retractors.

The incisions that are now usually practiced in resection of the wrist-joint are Lister's double dorsal and Langenbeck's dorso-radial, of which the latter is preferred by König, who strongly recommends it.

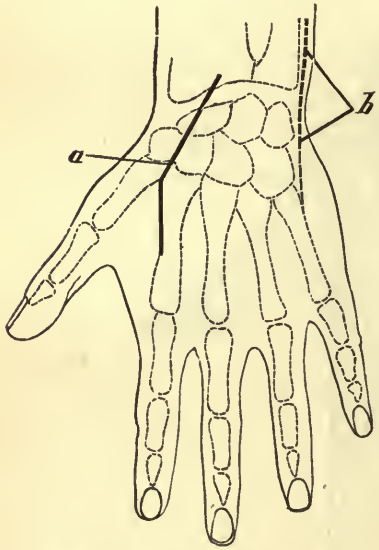

FIG. 65.—LISTER'S DOUBLE INCISION.

Clinical Studies.—Ollier ("Del a resection radio-carpienne." *Bull. de la Soc. de Chir.*, T. ix) makes his incisions according to the primary starting-point of the disease. If the disease commenced in the radius and extended later to the carpal bones, he removes the diseased bones through two lateral incisions; on the other hand, if the carpus was primarily affected he makes one dorsal incision and exercises great care not to injure any of the tendons of the extensor muscles. He reports twenty-four cases of excision of the wrist-joint, in twenty-two of which the operation was made for caries of the joint. Three of the patients died,—one of sepsis and two of pyæmia. He believes it is necessary to keep the patient under observation for at least six months, in order to carry out the necessary after-treatment, for the purpose of securing a satisfactory functional result. In many of his cases the functional results were highly satisfactory. Bidder, Heuter, and Langenbeck favored early resection for tubercular affections of the wrist-joint.

Fahrenbach (*Deutsche Zeitschrift f. Chirurgie*, B. xxv

Heft 1 and 2) reports twenty-eight cases from the clinic in Goettingen, in which resection of the wrist was performed for tubercular disease, and proceeds to analyze them with a view to determining the value of the operation in its final curative effect, and in order more accurately to recognize the indication for resection of this joint. König's method of resection for this joint is based upon the observation that the carpus is generally primarily attacked. Langenbeck's dorsal incision on the radial side is made, after application of Esmarch's bandage, and the joint opened on the radial side of the extensor tendon of the index finger. After drawing aside the tendons with retractors, the carpal bones are removed by means of a large Volkmann spoon. Finally, all diseased soft tissues and portions of approximate bones, if affected, are removed, and the cavity irrigated, iodoformized, drained, and antiseptically dressed. The hand is maintained in a position of dorsal flexion, at first by the fixation dressing, afterward by a suitable apparatus of steel and leather. Passive movements of the fingers are continued from the third to the sixth week. In twenty-two cases the whole carpus was removed in the manner above described, although the bones were not all affected. No deaths occurred from the operation; recovery took place within a period varying from one month to a year. In five cases it was impossible to obtain information subsequently to their discharge from the hospital. In sixteen cases a small fistula remained,—not, however, interfering with the use of the hand. Two of the patients died two and six months respectively after operation, in consequence of other tubercular affections. Secondary amputations were not necessary, but smaller operations, such as curetting the fistulæ, etc., were resorted to in six cases before the wound finally healed. The functional result was not perfect in any of the cases. In two cases the use of the hand was nearly normal. In eleven cases the patient could use his hand to work in the field and perform other diverse manual manipulations. In three cases the impairment of function was less satisfactory, and in three additional

cases the hand could only be used for holding things. Contrary to Bidder and Schede, König insists on the importance of removing, in every case, the entire carpus, whether all the bones are diseased or not. According to his experience, it is only by following this advice that satisfactory results can be obtained. It is also equally important to maintain the hand in dorsal flexion during the whole time of healing and for some time subseqently by means of suitable mechanical contrivances.

Resection.—Hoffman (*Deutsche Med. Wochenschrift*, December 25, 1890), in a case of extensive disease of the wrist-joint, connected Langenbeck's radial and Lister's ulnar incision by a third, transverse cut, corresponding to the articulation between the two rows of metacarpal bones. The two flaps were dissected upward and downward separately, and the whole diseased focus removed *en masse*, including the carpal end of the metacarpal bones and the distal extremities of the radius and ulna. The diseased portions of the extensor tendons of the hand and fingers, with their sheaths, were also removed. The resected surfaces were brought together by periosteal catgut sutures, and the ends of the carpal extensors sutured to the metacarpal periosteum and to the tendons of the extensors of the fingers. The wound healed by primary union, and the functional result was satisfactory and gradually improving. For good reasons, König insists that, after resection of the wrist-joint, the hand should be dressed in a position of one-third dorsal flexion until the new joint is firm enough to furnish the necessary support, as otherwise displacement of the resected ends is very liable to occur. He maintains this position for six months by means of a simple dorsal splint, from which the fingers are excluded. The results of resection of the wrist-joint were quite satisfactory even before antiseptic surgery came into use. Of seventeen cases reported by Gurlt in 1865 only three died, and of these three deaths two were caused by tuberculosis. Of fifteen cases Lister lost only two, and in these the cause of death had no connection whatever with the operation. The functional result

has seldom proved satisfactory. Only in two-thirds of the cases did the hand become useful. In tuberculosis of the wrist-joint in which the iodoform injections have been thoroughly tried and have been found inefficient, resection of the entire wrist with the articular surfaces of the radius and ulna and the heads of the metacarpal bones should be done, as partial resection is very liable to be followed by local recurrence. The functional result in many of these cases is excellent, even in persons somewhat advanced in years.

A man, 44 years of age, the subject of typical tuberculosis of the wrist-joint, came under my care at the Milwaukee Hospital. The clinical history did not reveal any hereditary tendency to tuberculosis in his family, and he was otherwise in excellent health. Patient can remember from boyhood the existence of a swelling in the palm, which, on flexion of the hand and fingers, would slip up under the annular ligament. The exact time when the present joint affection commenced he cannot recall; for the last two years, however, the joint has been swollen, and he was unable to use the hand to any extent. The bone is now slightly flexed and fingers contracted; the whole joint uniformly swollen and œdematous. Extension increases the pain. Operation, January 6, 1890: Straight dorsal incision. Tendons were carefully separated over the centre of the joint, and kept out of the way by blunt retractors. All of the carpal bones and articular extremities of radius and ulna, as well as every vestige of the infected soft structures of the joint, were removed. After iodoformization of the wound-surface the wound was sutured and dressed antiseptically, and the forearm and hand immobilized in a plaster-of-Paris splint. Wound completely healed in seventeen days. Hand kept in extended position for six weeks longer, after which patient had good use of hand, and function improved steadily for nearly a year, when he could do the ordinary work of a farmer.

Spina Ventosa.—The term *spina ventosa* has been em-

ployed for a long time to designate a spindle-shaped enlargement of the long bones of the hand and foot, which the old authors almost uniformly regarded as one of the manifestations of scrofula. As the term is still being used largely and has no reference to the etiology, the modern definition of the affection should be "tubercular osteomyelitis of the long bones of the hand and foot."

Böttchers ("Abhandlung von den Krankheiten der Knochen, Knorpel, und Sehnen," B. cxi, p. 121. Königsberg, 1792) gives the following strange definition of it: "Den Winddorn, spina ventosa, auch cancer ossis, Teredo, Wurm im Knochen, gangræna ossis genannt, nennet man diejenige Caries, die im Inneren des Knochens anfängt, von hier nach aussen gehet, und wobey heftige Schmerzen, Aufblähung des Knochens und ein Ausfluss einer stinkenden Gauche ist."

He believes that this affection sometimes follows small-pox, and alludes to syphilis as a possible cause, but regards it in most cases as a scrofulous affection of bone. He is conservative in his treatment, giving preference to opening of the diseased bone and removal of the inflammatory product to amputation.

Benj. Bell, in his classical treatise ("On Diseases of the Bones," 1828, p. 128), gives an excellent description of the macroscopical appearances of central tubercular osteomyelitis of the bones of the hand and foot: "On cutting into the swelled bone the shell of the tumor appears remarkably attenuated, and is in some places no thicker than common writing-paper, and part of the osseous parietes, indeed, is often absorbed. From the internal surface, which is lined by a delicate membrane, small spiculæ and plates of bone sometimes project. The contents of the tumor consist of a sero-purulent matter, combined with a substance not unlike gelatin in appearance." In spina ventosa the disease commences in the medulla of the bones, and is very correctly described as a tubercular osteomyelits. If the process is rapid sequestration may take place, the dead bone

showing varying degrees of density, according to the extent with which it was affected by the disease. More frequently the process is slow, and the inflammation results in the formation of an extensive soft mass in the interior of the bone, which, however, as a rule, is more diffuse than is the case in the epiphysial extremities of the larger long bones. The enlargement of the bone, which often takes place to an enormous extent, is due to the expansion of the bone by the accumulating product of tubercular inflammation within and by new formation of bone externally from the periosteum.

Renken ("Die Osteomyelitis der Kleinen Röhrenknochen an den Händen u. Füssen scrophulöser Kinder in ihrer Beziehung zur Tuberculose." *Jahrb. f. Kinderheilkunde*, B. xxv, S. 215) examined the inflammatory product in the granulation tissue, removed by scraping, in five children suffering from spina ventosa, and found tubercle bacilli in all of them. Spina ventosa is a disease of infancy and childhood. Goetz ("Étude sur la spina ventosa." *Thèse*, Paris, 1877) has tabulated thirty-five cases of spina ventosa, with a view to ascertain the age of patients suffering from this form of tuberculosis, with the following result:—

1 to 4 years,	23
4 to 8 years,	7
8 to 15 years,	5

He is of the opinion that the disease only affects the shaft of the long bones of the hand and of the foot, and always commences in the medulla, the bone becoming affected secondarily.

Unger ("Zur Pathologie und Therapie der Spina ventosa." *Arch. f. Kinderheilkunde*, 1889, Heft xi) has collected, during the last six years, the clinical histories of eighty patients that were treated, in the Jewish Hospital in Berlin, for spina ventosa, or ostitis tuberculosa of the shaft of long bones, as he calls it. Of this number forty-five had not reached the age of 5 years, the remaining patients were older, and five had passed the tenth year. The oldest patient was 15. The metacarpal bones

were most frequently the seat of the disease, namely, 40 times; then followed the phalanges of the fingers, 38 times; the metatarsal bones, 13 times; the phalanges of the toes, 3 times; ulna and tibia, each, 3 times; radius and inferior maxilla, each, 2 times. The observations made in connection with these cases showed plainly enough that, in order to obtain a good functional and cosmetic result, it is necessary to operate early.

Treatment.—In order to show what progress has been made in the surgical treatment of tuberculosis of bone during the last fifty years, I will quote Benj. Bell on the treatment of spina ventosa: "The treatment of spina ventosa is very simple, as the surgeon, when he is assured of its existence, must at once have recourse to the amputating knife. If the disease is seated in the bones of the metacarpus or metatarsus, as is generally the case in childhood, they should be removed at their articulations. If it has attacked the tibia and fibula, or radius and ulna, the amputation may be performed either at the knee or elbow or a short way above these joints. The general rule to be observed is that the entire bone in which the disease has its seat should be removed." Spina ventosa presents the most favorable conditions for successful treatment by means of parenchymatous injections of iodoform emulsion or other antibacillary agents. The compact layer of the bone has become so much expanded by the increased intra-osseous tension and has been rendered, at the same time, so osteoporotic that it can be easily penetrated with the needle of an ordinary hypodermatic syringe, which is also used for injecting the emulsion or solution. When the procedure is repeated the puncture should be made in a different direction, so that gradually the whole intra-osseous focus is saturated with the antibacillary remedy. If the affection does not yield to this method of treatment, or if fistulous communications already exist, the bone should be exposed at a point where it is most superficial and where important structures, such as tendons, large vessels, and nerves can be avoided, and, after incising and reflecting the periosteum, the whole

length of the focus is exposed by removing the external compact layer with a small chisel, when the tubercular product is carefully scraped out with a sharp spoon and the resulting cavity treated in the same manner as in operations for similar lesions on large bones, — iodoformization and packing with decalcified antiseptic bone-chips, — after which the periosteum is stitched over the packing and the external wound closed in the usual manner. Amputation can only come up for consideration if this operation prove a failure, or when one of the adjacent joints has become invaded.

CHAPTER XXXV.

Tuberculosis of Hip-Joint.

Morbus coxarius, coxitis, and hip disease are terms used to designate a tubercular inflammation of the hip-joint. The causation and nature of chronic inflammatory affections of this joint have been the subjects of a great deal of discussion and dissent for many years. The old authors regarded it as one of the local conditions caused by a scrofulous dyscrasia; more recently many have traced its etiology exclusively to trauma; but at the present time its tubercular nature is questioned by only a few.

Age.—Tubercular inflammation of the hip-joint is found more frequently in children than adults. Bryant ("On Hip Disease." *Medical Times and Gazette*, July 3 to October 16, 1869) observed three hundred and fifty cases of hip disease, and of this number 62 per cent. occurred in children less than 10 years of age and 80 per cent. before the twentieth year.

Primary Location of Disease.—In this, as in all diarthrodial joints, the disease may begin in the synovial membrane or in the bone; but, on account of the deep location of the joint, it is not easy, during life, to determine the relative frequency of each. König examined 15 museum specimens, and found that the disease had a primary osseous origin in 8, and synovial in 7. Haberern ("Ueber Beckenabscesse bei Coxitis und ihre Behandlung." *Centralblatt f. Chirurgie*, No. 1314, 1881) has found, in studying 132 cases of resection of the hip-joint, with special reference to the location of osseous foci, that in 50 cases caseous foci were present in the acetabulum 31 times with and 19 times without sequestra; in 23 the foci were located in the head or great trochanter of the femur 14 times with and 9 times without necrosis. In 29 cases carious defects in the acetabulum and neck of femur were so extensive that the exact location of the primary disease could not be ascertained. In 23 cases the

disease was probably of a primary synovial origin. Of 12 cases examined by Watson Cheyne (*British Medical Journal*, April 4, 1891), section showed primary osseous lesions in 5; in the rest it was somewhat doubtful as to whether the disease commenced in the synovial membrane, as he had not the opportunity to examine the acetabulum in all instances. He is, however, of the opinion that a primary osseous origin is more frequent in this than the knee-joint. Most authors agree that it commences more frequently in the acetabulum than the femur. In Haberern's 80 cases of primary bone disease in this locality the acetabulum alone was the seat in 50, the femur alone in 23, and both bones together in 7. In the femur the starting-point is most frequently in the neck, on the distal side of the epiphysial cartilage, the epiphysis itself being usually exempt. In the acetabulum it attacks the vicinity of the V-shaped cartilage. In the majority of cases the disease terminates in sequestration, caseous foci, without necrosed bone being comparatively rare.

In Haberern's 50 cases of primary acetabular disease, in 31 sequestra were present, in 19 no necrosis, while in the femur sequestra were present in 14 and absent in 9, and in the 7 cases where both bones were affected necrosed bone was found in 6 and absent only in 1. A primary focus in the neck of the femur grows in the direction of the epiphysial cartilage and toward the surface of the bone. When the disease reaches the synovial membrane the whole of the interior of the joint becomes rapidly involved. At the point of reflection of the synovial membrane it reaches the articular cartilage, which is affected from the sides and at the point of insertion of the round ligament almost simultaneously. The epiphysial cartilage is destroyed at the same time, resulting often in complete epiphysiolysis. If the primary focus is located near the trochanter major the disease may not extend into the joint, but remain extra-articular, and eventually the synovial membrane is apt to become involved during the progress of the disease. The extensive destruction of the bony constituents of the joint is brought about by extension of the

tubercular process and the rarefying osteomyelitis which attends it. The pressure between the articular surfaces, caused by reflex muscular contractions, is an important element in the speedy and extensive destruction of bone in tubercular disease of this joint. The acetabulum enlarges in an upward direction under the pressure exerted by the head of the femur, giving rise to shortening of the limb. True dislocation may be caused, in such cases, by the slightest application of force, under such circumstances, and sometimes this accident occurs when the articular surfaces have not been much affected, if the soft structures of the joint have undergone extensive disease. A partial dislocation is quite common in connection with destruction of the rim of the acetabulum. Complete dislocation is often prevented by the formation of a buttress of new bone by plastic periostitis.

Symptoms.—Only a few of the more conspicuous symptoms of coxitis will be discussed here. The sympathetic pain in the knee-joint which is so often associated with the osseous form of hip disease has, up to date, not been satisfactorily explained. Various theories have been advanced, but none of them fully explain this phenomenon.

Sir Charles Bell believed that the pain is communicated by means of the obturator nerve. "The obturator nerve," he says, "passes through the thyroid foramen down to the hip-joint, and, after supplying the muscles, is distributed upon the inner part of the knee. The nerve, in its course, is thus involved in the inflammation which affects the hip-joint, and the pain is referred to its extensive cutaneous branches at a part distant from the seat of the disease."

Coulson ("On Diseases of the Hip-Joint," etc. London, 1841) maintains that the pain in the knee commences with the extension of the disease to the capsule of the joint. As the pain sometimes extends to the middle and outer part of the thigh, in localities out of reach of the obturator nerve, he explains this symptom by the intimate connection which exists

between the long head of the rectus femoris muscle with the outer edge of the acetabulum and with the capsular ligament, believing that the fascia of this muscle may take on the inflammatory action, and the pain in this way be conveyed down the limb to the thigh. He argues that we have an analogy to this in disease of the shoulder-joint, the pain in these cases often extending down the front of the arm to the insertion of the biceps. The different faulty positions of the limb, from slight flexion and rotation outward, characteristic of the first stage to the most aggravated deformity attending or simulating complete dislocation, have also been extensively discussed and variously interpreted.

FIG. 66.—COXITIS, LEFT SIDE.

Slight abduction and rotation of limb outward and apparent elongation of limb. Gluteal crease diminished and lower down, nates flattened.

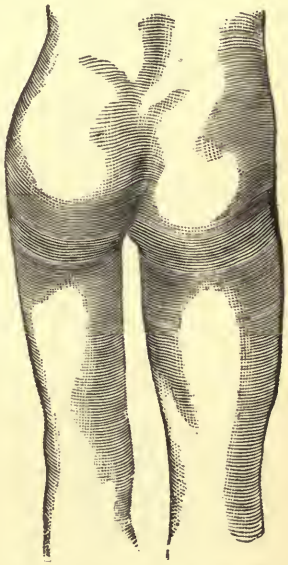

FIG. 67.—COXITIS, LEFT SIDE, SECOND STAGE.

Limb shortened, adducted, and rotated inward, nates preternaturally pre-eminent and elevated. Gluteal crease higher than on opposite side.

F. Busch ("Ueber Coxitis." *Deutsche Med. Wochenschrift*, No. 14, 1878) claims that the primary abduction and rotation outward in coxitis are caused by tension of the ilio-femoral

ligament, as the intra-capsular inflammatory product crowds the head of the femur away from the acetabulum. If, later, the acetabulum is dilated by pressure of the head of the femur, the head slips backward and the tension of the same ligament then rotates the limb inward. In opposition to this explanation Kolaczeck ("Die Ætiologie der mechanischen Symptome bei der Hüftgelenkentzündung der Kinder." *Deutsche Med. Wochenschrift*, Nos. 31–32, 1878) supports the accommodation theory to explain the position of the limb in coxitis. In the first stage the limb is abducted in order to bring the pressure-point outward, thus

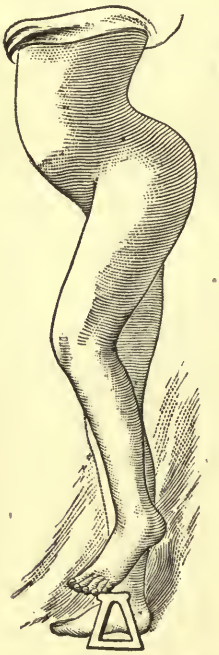

FIG. 68.—THIRD STAGE OF COXITIS.

The characteristic deformity of second stage greatly aggravated.

FIG. 69.—THIRD STAGE OF COXITIS.

Limb greatly shortened and rotated outward.

taking off the pressure from the extremity. Rotation outward takes place to prevent pes varus position of the foot. Flexion of the thigh upon the pelvis has for its object to bring the pressure-point nearer the anterior portion of the upper rim of the acetabulum, which also aids in the diminution of pressure, while the limb is placed in a semi-flexed position. In the later stages of the disease flexion is maintained by the contracted fascia.

The second stage indicates the existence of beginning destruction of the bony constituents of the joint attended by permanent deformity. The third stage is characterized by a position of the limb which characterizes partial or even complete dislocation of the hip in the direction of the dorsum of the ilium. The prolonged muscular contractions and traction of the shortened anterior portion of the capsular ligament, combined with destruction of bone by the tubercular inflammation and pressure atrophy, lead to this result.

FIG. 70.—POSITION OF LIMB IN DORSAL RECUMBENT POSITION OF PATIENT DURING THE EARLY STAGE OF COXITIS.

If separation of the head (epiphysiolysis) take place, or if the neck of the bone is extensively destroyed, the limb may rotate outward, and the conditions then presented resemble a fracture of the neck of the femur.

FIG. 71.—TILTING OF PELVIS AND CURVING OF SPINE WHEN AFFECTED LIMB IS BROUGHT DOWN EVEN WITH THE LIMB ON OPPOSITE SIDE.

One of the earliest and most significant symptoms of coxitis is an inability on the part of the patient to extend the thigh fully and the failure on the part of the surgeon to correct the flexion without the use of an anæsthetic to the extent of securing perfect relaxation of the muscles.

Aggravation of pain by pressure against the sole of the foot when limb is extended, and against the great trochanter in the direction of the neck of the femur, as well as on active and passive motion of the joint, is an important and early symptom.

Atrophy of muscles is a constant and well-marked symptom in tubercular inflammation of this as well as any other joint.

Prognosis.—The prognosis in coxitis is greatly modified by the age of the patient, the stage of the disease, and the general condition of the patient. It is much more favorable in children than adults. Coxitis which has advanced to the formation of abscesses in adults necessarily gives rise to a very unfavorable prognosis, and the prospects of a favorable termination by operative treatment under these circumstances are indeed very doubtful. The co-existence of tuberculosis in other joints or organs, or amyloid degeneration of important internal organs, is almost sure to lead to a fatal termination, irrespective of the primary joint-lesion. Appropriate early local and general treatment is of the greatest value in arresting the disease before irreparable destructive changes have occurred, and in preventing re-infection of the body from the affected joint.

Ford ("Observations on the Disease of the Hip-Joint," etc., p. 9. London, 1810) expected more from treatment of hip-joint disease in its incipiency than most of his contemporaries. "As far as my experience goes, the ill success attending the treatment of these cases has been more owing to a want of distinguishing properly the nature of the complaint in its early period, or to the neglect and indifference of the patients themselves, than to the incurable nature of the malady, or to a defect of power in the healing art."

If the patient is young and the general condition favorable, efficient local and general treatment often results in a cure without the formation of abscesses, with a somewhat stiff but useful joint. Very often, ultimately, recovery takes place after the joint has suppurated for years, resulting in extreme emaciation of the patient; but in such instances bony ankylosis, with the thigh flexed and the limb shortened, abducted or adducted, is the rule. Such an event, however, is only possible when the tuberculosis is limited to the joint and when the internal organs remain healthy.

TREATMENT.

Extension and Fixation.—Benj. C. Brodie ("Diseases of the Joints," p. 139. London, 1850) gave extension a trial, but the means employed were so imperfect that the method could not be satisfactorily carried out. "In some cases where, the disease being in an advanced stage, there seemed reason to apprehend a displacement of the head of the femur, with a retraction of the limb, I have endeavored to prevent it by the application of a moderate but constant extending force. For this purpose a leather strap was applied above the condyles of the femur, having a string attached to it, passing over a pulley,

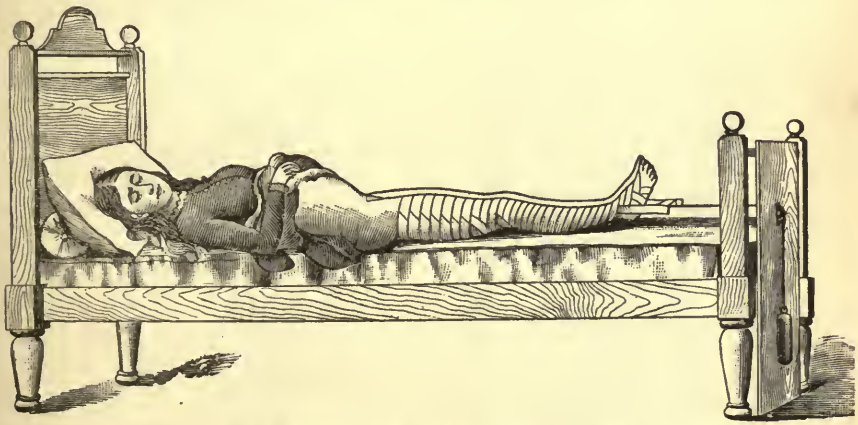

FIG. 72.—EXTENSION BY WEIGHT AND PULLEY.

fixed, at a moderate height, to the lower end of the bedstead, and supporting a light weight, the pelvis being at the same time fixed by a strap to the middle or upper end of the bedstead. This, in some instances, seemed to relieve pain, and I am inclined to think that it was useful otherwise, by counteracting the muscles, which tended to draw the limb upward. However, it almost always happened that something occurred to prevent the experiment being fully and fairly tried; and all I can venture to say respecting it is, that it may be worth while, in certain cases, to give this mode of treatment a further trial." The value of extension, in the treatment of inflammation of the hip-joint,

is admitted on all sides, but the methods of carrying it out vary. *Extension by weight and pulley with the patient in the recumbent dorsal position is the most efficient, and should be resorted to in all cases in which pain is a prominent symptom and where the muscles around the hip-joint have become contracted.* Extension in such cases usually promptly relieves the pain and not only prevents further contraction, but is one of the best means to correct displacements. Extension is applied in the same manner as in

FIG. 73.—THOMAS' SPLINT ARRANGED FOR WALKING, WITH CRUTCHES AND PATTEN UNDER FOOT ON SOUND SIDE.

FIG. 74.—DOUBLE THOMAS' SPLINT.

fractures of femur,—by strips of adhesive plaster, which should extend a considerable distance beyond the knee-joint. The weight to be employed must be adjusted to meet the indications of each individual case,—from two to fifteen pounds, according

to age of the patient and the degree of contraction and sense of relief. A good rule is, to rely on the sensation of the patient in the matter of weight, commencing with a light weight and increasing it gradually until pain is relieved, when it can be said that extension has been carried to the point of comfort. *Extension by the different kinds of walking splints cannot be relied upon in cases in which this method*

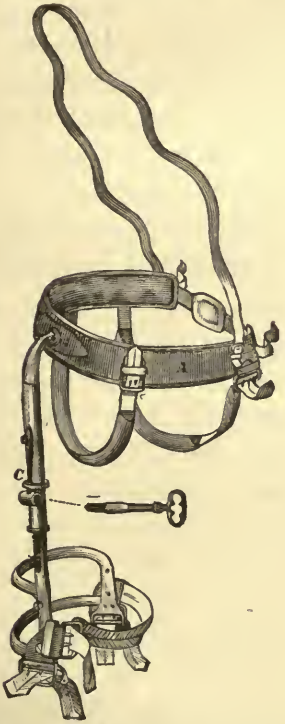

FIG. 75.—SAYRE'S LONG HIP-SPLINT.

FIG. 76.—VOLKMANN'S SPLINT APPLIED.

of treatment is indicated. Auto-extension, as advised by Hutchinson, is an exceedingly valuable aid to the treatment during the early stage of the disease, before much contraction has taken place; also as a means of continuing this principle of treatment after extension by weight and pulley has been discontinued, and during the treatment after resection of the hip-joint.

Fixation of an inflamed joint is one of the most important elements of successful treatment. The numerous mechanical devices which have been invented and manufactured for making extension have proved useful not on account of the *traction which they were supposed to effect*, but as a means of procuring immobilization. Of the different walking splints invented for the purpose of making extension, those of Thomas, Sayre, and Volkmann are the best.

If the limb is in normal position, or has been brought in this position by extension, fixation of the joint and immobilization of limb can be secured in a plaster-of-Paris bandage extending from the toes and embracing the entire limb and the pelvis. With such a dressing the patient can be taken out-doors and can walk on crutches, as during walking the necessary extension can be made by suspension of the affected limb if the shoe on the opposite side is supplied with a raised sole, as advised by Hutchinson. This method of treatment should be continued until the inflammation in the joint has subsided,—a condition which can be determined by disappearance of pain and tenderness and subsidence of any tendency to further contraction of the flexor muscles of the thigh. Intra-articular and parenchymatous injections of iodoform should be tried in all cases of primary and secondary tuberculosis of the hip-joint before and after the formation of para-articular abscesses, before resorting to excision of the joint.

Extra-articular Operations in Primary Osseous Tuberculosis of the Hip-Joint.—Mr. Symonds (*British Medical Journal*, May 16, 1891) has recorded two cases in which he removed a tubercular sequestrum from the neck of the femur without injury to the joint; the patients were aged, respectively, 3 and 5 years. In both there was a large chronic abscess on the front and outer aspect of the thigh, without any pain in the joint. Both children were able to walk with only a slight limp. The movements of the joints in each case were only slightly impaired. In the first case the presence and situation of the sequestrum

were suspected; in the second it was searched for after the abscess was opened. In both a minute sinus was found leading through the front of the neck into a cavity. The channel was enlarged by gouging away a little bone from the outer side and the sequestrum removed. In both the capsule was seen lifted up by the abscess; in the first it was accidentally opened by a slip of the knife; in the second it was intentionally pricked, and in both cases a few drops of clear fluid escaped. Both sequestra involved the epiphysial aspect of the neck, and in the first case the piece of bone was of considerable size. In the first case, operated on in 1887, the wound was stuffed and drained. In the second, operated on in May, 1889, according to the method introduced by Mr. Barker, the large abscess, after being scraped out, was sewn up, and this was followed by primary union. At the time the report was made the elder patient, a boy aged 7, had a perfectly useful joint, possessing all the normal movements, and, moreover, there was no shortening and no irregular growth. The other, the first operated on, had a limb of normal length, but the joint was fixed. At the same time Watson Cheyne (*ibid.*, p. 1073) reported three cases of tuberculosis of the neck of the femur in which sequestra were removed from the usual situation below and just outside the epiphysial line without any suppuration being present. The diagnosis was made first by excluding acetabular disease by rectal examination, next by thickening about the trochanter and neck of the femur implying bone disease, and, thirdly, by thickening of the capsule implying communication with the joint. In a fourth case absence of thickening of the capsule showed that the disease in the bone did not communicate with the joint, and, therefore, did not involve the surface of the bone, and consequently an incision was made over the outer side of the trochanter and a channel scooped out along the neck of the femur till a caseous mass was found just outside the epiphysial cartilage. The case made an excellent recovery. A similar case from Volkmann's clinic was previously alluded to. (Fig. 20.)

The frequency with which coxitis commences on the acetabular side should lead surgeons to search early and carefully for osseous foci in the innominate bone near the acetabulum, and, if such foci can be located with a sufficient degree of accuracy, extra-articular operations would not only be indicated, but would prove successful both as curative and prophylactic procedures. According to the location of the focus, a large anterior or posterior incision would be required to locate and remove the diseased tissue.

Arthrectomy.—Schede has made a number of attempts to substitute the more conservative operation of arthrectomy for typical resection in synovial tuberculosis of the hip-joint. He makes a large, posterior, curved incision, divides the posterior portion of the capsular ligament, and dislocates the head of the femur upon the dorsum of the ilium and extirpates the synovial membrane with the capsule and ligamentum teres. After removal of all of the infected tissues and thorough iodoformization of the joint, the head of the bone is reduced and the wound treated in the same manner as after resection. Three years ago I had the pleasure of being present at one of these operations while visiting his clinic, and became fully convinced of the many difficulties which surround an arthrectomy of this joint. Even if the results should warrant such an operation, its scope will always remain limited on account of the frequency with which synovial tuberculosis of this joint is complicated by disease of the acetabulum, head or neck of the femur.

Resection.—Benjamin C. Bell ("Diseases of Joints," p. 141. London, 1850) regards resection of the hip-joint appropriate only in cases where the head of the femur is found dislocated on the dorsum of the ilium and can be distinctly felt through the attenuated soft parts, and even in such cases the procedure does not meet with his approval, as may be seen from the following: "In such a case it has been proposed to make an incision on it (the head of the femur) and remove the head and neck of the femur by a saw. It would appear that this operation has

been actually performed with some degree of advantage, and I do not doubt that circumstances may occur to make it worth while to have recourse to it; but it is to be observed, at the same time, that all that can be thus accomplished is the removal of one portion of the disease, and that it is the largest portion of it, in the bone of the pelvis, which is necessarily allowed to remain. The operation cannot be performed without a certain degree of local disturbance and more or less loss of blood, and, taking all these things into consideration, I conceive that we should not recommend it except where some very unequivocal advantage may be expected from it."

Since the time this was written a radical change of opinion in reference to the propriety of operative interference in hip disease has taken place. The operation is now almost universally sanctioned in all cases where mere expectant treatment, such as extension, fixation, and parenchymatous and intra-articular injections have failed to arrest the progress of the disease, and the general condition of the patient furnishes no contra-indication.

RESECTION OF HIP-JOINT.

History.—Removal of the necrotic head of the femur was made by a surgeon, according to Schlichting, in 1742 ("Philosophical Transactions," 1742); by Vogel ("Observ. Chirurg.," 1771), Hoffman ("Vom Scharbocke," 1782), Ohle (Schmidt's *Jahrbücher*, B. xi, p. 116), Schmalz, and Hedenus ("De Femor. Amp.," 1816, p. 65), but the first typical resection was made by Anthony White, in 1815 (Cooper's "Surgical Dictionary," seventh edition, p. 272). Mr. White's case of resection of the hip-joint presents more than ordinary interest, and deserves to be fully recorded here: "John West, a twin of delicate make, was born and resided in Westminster. When between 4 and 5 years old he suffered from scrofulous inflammation in the left hip-joint, which passed through the stages of elongation, dislocation, and subsequent retraction, and the femur was finally lodged in a very high position, on the dorsum of the

ilium. About three years subsequent to the commencement of the disease, and when he was 8 years old, I first saw him. He was much emaciated; several abscesses had formed, during this period, around and over the diseased structures, leaving many fistulous openings, through which the probe easily detected the surface of the displaced bone to be in a state of caries, and several small exfoliations had occurred from the ilium, ischium, and of pubes, over which bone-abscesses had formed. In the progress of the disease the knee of the affected limb had become inverted and firmly imbedded on the lower and inner part of the opposite thigh, from which position it could not be removed. The boy being placed on a table of convenient height, I proceeded to divide the integuments covering the bone, carrying the incision from an inch above the head directly along the middle line of the bone, about two inches below the trochanter; this was completed at one incision, down to the surface of the bone. The integuments were dissected inward and outward, thus leaving the bone entirely bare a little lower down than the lesser trochanter, which was distinctly visible. A spatula was now placed under that part of the bone which was intended to be sawn through, so as to protect the structure underneath; a smaller spatula was then introduced into the space made by the saw, and used as a lever to raise the bone, which, with a little dissection, was removed from the dorsum of the ilium. No vestige of the acetabulum remained, neither was any caries of the ilium discovered. The thigh was now readily brought into a straight line, and the knee liberated from its position on the thigh. The wound was closed by adhesive plaster, and no portion of the bone was left exposed. Splints and an eight-tailed bandage were applied, and the limb placed in a straight position. The head, neck, and trochanters were very apparent, the caries being superficial, and not extending lower than the lesser one." The patient made a good recovery, and at the end of two months was able to move the limb.

Incision.—Straight incision, commencing two inches above

the trochanter, in the long axis of the bone, and terminating four to five inches below trochanter,—White, Langenbeck, and others. A similar, slightly-curved incision, but parallel to posterior margin of trochanter major, devised by Sayre. A similar incision, but somewhat more curved, was made by Jäger and Textor in front of the trochanter major, while Chassaignac and Ure made the curve behind. Transverse incision in the line of the neck of the femur dividing the iliacus, sartorius, rectus, and tensor fasciæ was recommended by Roser. It was the intention of Roser to preserve the trochanter major. This incision was adopted by Maisonneuve and Esmarch. J. H. Heyfelder combined a short transverse with a long, slightly-curved, longitudinal incision. Textor recommended two long longitudinal incisions, one in front and the other behind the great trochanter, uniting them above, at the middle of the upper margin of the great trochanter. Jäger and Ried made a similar flap, but with a more acute angle. Sédillot and Jones made a semicircular flap, with the base directed downward; Velpeau a similar flap, but with the base in the opposite direction. Roux and Percy recommended a quadrangular flap, with base directed upward. The incisions that are now most in use are: The straight anterior, straight over trochanter major, or along its posterior border, and slightly curved incision, with concavity directed toward trochanter major.

Modern Operative Technique.—König's operation of excision of the hip-joint has been fully described in the chapter on "Resection." (See Fig. 38.) It is an operation that yields excellent results. In the same place was described an operation which is destined, in the near future, to supersede the operations now usually practiced, and is best adapted for all cases in which it is not deemed necessary to make a typical resection. In this operation temporary resection of the trochanter major is made, and thus an important part of the upper portion of the femur, seldom the seat of disease, is preserved, and the

attachments of numerous important muscles are not interfered with. The more I see of this method, and observe its results, the more I appreciate the many advantages it possesses over the operations usually practiced. This method secures free access to the joint, and by it important structures concerned in a satisfactory functional result are preserved. Removal of the whole neck and shaft of the femur down to the trochanter minor will be practiced no longer, unless these structures are involved by the disease. The modern methods of

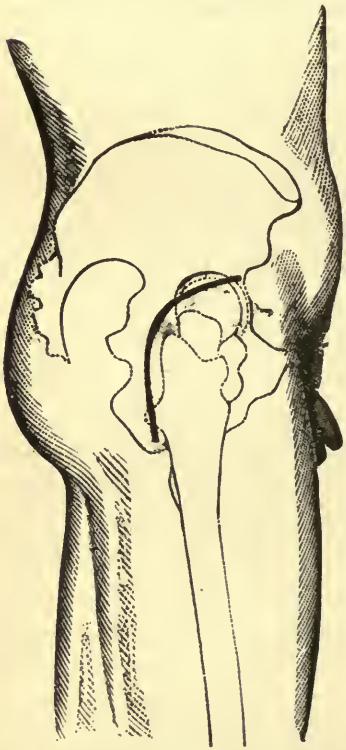

FIG. 77.—WHITE'S POSTERIOR CURVED INCISION.

FIG. 78.—LANGENBECK'S LONGITUDINAL INCISION.

resecting the hip-joint aim at thorough removal of all diseased tissue and conservation of such portions of the neck and shaft as are free from the tubercular process. Efforts in this direction have been made for many years, but the operative technique is undergoing constant improvement, and, with this aim in view, it is to be hoped that the operation will reach perfection in the near future.

Schede ("Ueber Methodik und Nachbehandlung der Hüftgelenk resection." *Verh. der Deutschen Gesellschaft f. Chirurgie*, 1878) in 1878 described his method of resection of the hip-joint by an anterior incision and the decapitation of the head of the femur,—an operation which in his hands yielded excellent functional results. It was generally believed, at that time, that the removal of the head of the femur alone would result in ankylosis, but Schede's cases demonstrated that this fear is not based on facts. In the discussion of Schede's paper, Hueter spoke in favor of the anterior incision, only

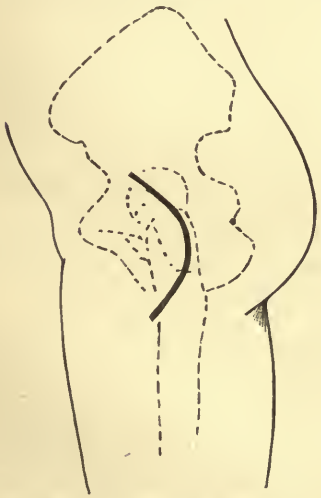

FIG. 79.—SAYRE'S LINE OF INCISION.

FIG. 80.—M. J. ROBERT'S OPERATION OF EXCISION OF THE HIP-JOINT.

he deviated from Schede's method by making the incision on the outer side of the sartorius muscle, at a point near the neck of the femur. Langenbeck laid it down as a rule that if the head alone was affected decapitation should be done and all intact

portions of the bone preserved. He believed that, in many cases, the head of the bone would be reproduced in the same manner as in Heine's experiments on dogs. He gives Schede's incision the preference in children where the head of the bone has separated, and in gunshot wounds of the hip where it is necessary to remove head and fragments of bone.

Neuber ("Ueber Hüft-und Kniegelenk resectionen." *Verh. der Deutschen Gesellschaft f. Chirurgie*, 1884) removes what is necessary of the constituent parts of the hip-joint, after making a temporary resection of the trochanter major. The trochanter is exposed by making an oval flap with the base directed toward the anterior superior spinous process of the ilium, which, with the trochanter attached, is drawn in an upward direction. With a hollow chisel, the upper posterior portion of the rim of the acetabulum is removed, after which the head of the femur can be readily dislocated and as much of the bone removed as may be necessary. After extirpation of the diseased capsule the parts are replaced in their normal relations. The wound is united by deep and superficial sutures, and drainage secured in the lower angle of the wound. The limb is kept in abducted position, and the dressing usually allowed to remain from four to six weeks. Rest in bed and extension in abducted position of limb are necessary for at least six weeks. Auto-extension during the day and extension by weight and pulley at night should be continued for at least six months.

Krause ("Ueber die Behandlung und besonders über die Nach behandlung der Hüftgelenks resection." Langenbeck's *Archiv f. Chirurgie*, Bd. xxxix, S. 466), after an experience of three hundred and eight resections of the hip-joint that have been performed in the clinic at Halle, of which two hundred and seventy were done for caries, again calls attention to the necessity of continuing extension by weight and pulley for at least two years, during the night, after the operation, in order to prevent unnecessary shortening of the limb. In children, the weight applied varies from twelve to twenty-five pounds. The

limb is placed in abducted position. In case the wound heals by primary intention, the patient is allowed to leave his bed at the end of eight days. Passive motion is advised at the end of three or four weeks. The child is allowed to walk with the assistance of a walking stool devised by Volkmann (see p. 375), as he considers this preferable to crutches. He is opposed to plaster-of-Paris dressings and Taylor's apparatus. I have been in the habit of following Volkmann's advice until the wound is healed, after which I allow the patients to walk on crutches, the limb suspended by Hutchinson's method, and extension by weight and pulley during the night, and the results have been such that I can strongly recommend this plan of treatment.

Partial Resection of Head of Femur.—Bardenheuer ("Resection der Huftgelenkspfanne u. partielle Resection des Oberschenkel Kopfes." *Archiv f. klin. Chir.*, xlii, p. 375) advocates partial resection of the head of the femur in cases requiring excision for tubercular affections, and in which a part of this portion of the bone can be saved. He makes the external incision parallel to the anterior border of the trochanter major from ten to fifteen centimetres in length, extending at least ten centimetres above the trochanter. At the lower end of the incision he at once works his way down to the bone, separates the periosteum from the femur, and enters the joint by following the anterior surface of the neck of the femur. The capsule is then lifted off with the elevator, or cut through with knife or scissors. As soon as the joint is freely opened, the limb is strongly rotated outward so as to dislocate the bone in a forward direction. The affected portion of bone can now be removed,—a process which Bardenheuer calls *concentric resection*. The capsule is extirpated, and if the acetabulum is affected it is cleared out with a sharp spoon. During the operation the limb is changed in position so as to render all parts of the joint accessible. He reports a number of successful cases operated on by this method.

Proper mechanical treatment, after partial resection of the

hip-joint, is essential in obtaining speedy healing of the wound and in securing a satisfactory functional result.

Results.—The immediate and remote results are greatly influenced by the pathological conditions within and around the hip-joint, as well as the age and general condition of the patient. A granulating synovitis, with or without osseous foci, in an otherwise healthy child, presents the most favorable conditions for a speedy healing of the wound and a good functional result. Operations on suppurating hip-joints are seldom followed by primary healing of the wound, and this is often only accomplished after weeks and months of profuse suppuration. In cases of this kind, it often becomes necessary to make additional provisions for drainage, and to scrape out fistulous tracts before the wound finally heals. The shortening varies from a few lines to a number of inches. If shortening does not exceed an inch and a half the functional result is usually satisfactory. If the epiphysis is removed in young children progressive shortening is very liable to follow.

A suppurating hip-joint in adults warrants a grave prognosis. Anæmic patients and patients suffering from tuberculosis of other organs, or other serious complicating disease, are bad subjects for operative interference.

In the classical monograph on resections by Heyfelder, published in 1863 ("Lehrbuch der Resectionen." Wien, 1863), seventy-one cases of resection of the hip-joint are tabulated, and we find it stated that in thirty-three the operation proved fatal. Boeckel reported thirty-four cases of resection of the hip-joint; of this number twenty-two recovered and twelve died. The immediate causes of death in these cases were: shock, 3; meningeal tuberculosis, 4; exhaustion shortly after operation, 2; pelvic tuberculosis, 2; diphtheria, 1. Of the cases that recovered from the operation, 2 were lost sight of after a year; 2 died of tubercular meningitis,—1 three months and the other six years after operation; 2 died of albuminuria two and three years, respectively, after operation. Of the 9 that were living at the

time the report was made,—eighteen months to ten years after operation,—in 5 fistulæ existed, and only in 9 was the wound permanently healed.

Elben ("Ueber die Gebrauchsfähigkeit der Extremität nach der Resection im Hüftgelenk." Dissertation, Würzburg, 1878) studied the final functional result in sixty-one cases of resection of the hip-joint. In five of these cases the limb was

FIG. 81.—RESECTION OF HIP-JOINT FOUR MONTHS AFTER OPERATION. (*Barwell.*)

FIG. 82.—RESECTION OF HIP-JOINT TWELVE YEARS AFTER OPERATION. (*Barwell.*)

useless. Fifteen patients could walk aided by mechanical support, and forty-one had good use of the limb and could walk without assistance.

The more conservative operations on the hip-joint, in the operative treatment of tubercular affections, that are now gradually displacing typical resection will yield more satisfactory functional results, while the thoroughness with which osseous

foci, the diseased capsule, and infected para-articular tissues are now being removed will be less frequently followed by local recidivation.

Resection of Acetabulum. — Resection of the acetabulum for tubercular disease was devised by Schmid, of Stettin, and first practiced by him on the living human subject June 20, 1890. (James Kellogg, "Resection of Acetabulum." *Nashville Journal of Medicine and Surgery*, June, 1891.) The patient was a boy, aged 7 years, whose hip-joint was resected on the 5th of August, 1889, after being a sufferer from tubercular coxitis for two years. Soon after the operation fistulæ formed and suppuration set in, and the boy became greatly emaciated from the hectic fever and profuse purulent discharge. Scraping of the cavity proved of no avail. At the time mentioned, amputation through the hip-joint was made by the bloodless method as a preliminary step, whereupon the acetabulum was freely exposed by an incision over it and removed by sawing through the os innominatum in three places, beginning at the horizontal ramus of the os pubes, which called for an incision parallel to the horizontal ramus of the os pubes, and at a right angle to the first incision. The large vessels, together with the flap of the soft parts, were easily pushed out of the way, whereupon the ischium was sawn through, and, finally, the acetabulum was detached by sawing through the ilium at the desired point. The instruments used in making the sections were pistol-saw, chain-saw, hammer and chisel. The acetabulum, being now free, was separated from the pelvic fascia, while the large cavity resulting was stuffed with iodoform gauze. The hæmorrhage was moderate.

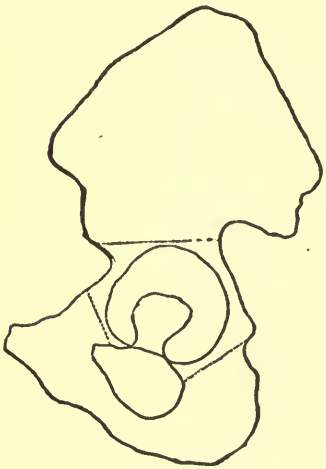

FIG. 83.—RESECTION OF ACETABULUM. SECTIONS THROUGH BONE.

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Suppuration ceased after the operation and the general condition of the patient improved. One small fistula which remained soon healed. The soft parts have produced a stump almost as large as the stump resulting from a high amputation of the thigh, which permits the application of a leather case to which an artificial limb is attached. The patient is able to walk well without crutch or cane. The second case, a girl aged 14 years, with tubercular coxitis, was resected August 27, 1889, and on March 4, 1890, the thigh was amputated through the hip-joint for similar reasons as in the first case. On August 20, 1890, the acetabulum was resected. The condition of the patient previous to the operation was far worse than in the preceding case. After the operation improvement followed promptly until the child was restored to perfect health.

The third case, a boy aged 13 years, was admitted into the hospital September, 1890, and resection was made at once for tubercular coxitis of two years' duration. The operation proved a failure, and on the 26th of November the acetabulum was resected without amputation of limb. It was found that the disease was limited to this structure. Union of wound by primary intention. Five weeks after the operation the boy was able to walk about alone without crutches.

Bardenheuer ("Resection d. Hüft gelenkspfanne," etc. *Archiv f. klin. Chirurgie*, B. xlii, p. 375) resects the acetabulum through an extra-peritoneal incision extending in a downward direction as far as the junction of the middle with the outer third of Poupart's ligament. The vessels and other soft parts are drawn out of the way by retractors; the periosteum over the portion of bone corresponding with the acetabulum is separated and the bone removed with a sharp chisel. If he make, at the same time, a partial resection of the head of the femur, what remains of this is fixed in the defect, and in several cases he obtained, by a combination of these two operations, excellent functional results,—movable, useful limbs.

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CHAPTER XXXVI.

Tuberculosis of Knee-Joint.

Of the large joints the knee-joint is most frequently the seat of tubercular disease, and is next in frequency to tubercular spondylitis. The description of the old authors of tumor albus apply to this joint. It is also in this joint that tubercular processes have been studied with the greatest care and thoroughness from etiological, clinical, and pathological stand-points. The description of tubercular joints, as found in text-books, is taken from the clinical appearances and pathological conditions of this joint when the seat of a tubercular affection.

Fig. 84.—Tubercular Synovitis of the Knee-Joint, with Effusion.

Age and Primary Location of Disease.—Although no age is exempt from tuberculosis in this locality, children and young adults furnish the largest number of cases. In reference to the location of the primary disease in this joint, Willemer's ("Ueber Kniegelenk tuberculose." *Deutsche Zeitschrift f. Chirurgie*, B. xxii, p. 268) investigations show that in patients less than 10 years of age it primarily attacks the synovial membrane in 39 per cent., and in 61 per cent. one or both of the articular extremities are the primary starting-points; between 10 and 20, 49 per cent. are synovial and 51 per cent. osseous; above 20 years of age, 33 per cent. are primarily synovial and 65 per cent. primarily osseous.

In 114 museum specimens König found that 69 were primarily osseous, 33 synovial, and 12 doubtful. He states that, in his own experience, the two forms are about equally frequent in youth, but in the aged there are three times as many osseous cases as synovial. Of 43 cases examined by

Cheyne (*British Medical Journal*, April 4, 1891), 16 were found to be synovial, 5 very probably synovial, 2 doubtful, and 20 osseous. In only 2 of the osseous cases were multiple foci present; in all the rest only one focus was found. Sequestration was found only in 7 of the osseous cases. In the osseous form

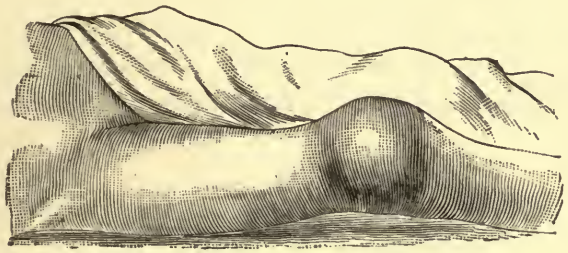

FIG. 85.—TUBERCULAR OSTEOMYELITIS OF INTERNAL CONDYLE OF FEMUR.

of knee-joint tuberculosis the primary disease in the bone attacks most frequently the epiphysis itself. The extension of the disease beyond the epiphysial line is unusually rare.

The internal condyle of the femur is most frequently affected, then the head of the tibia, and least in frequency the

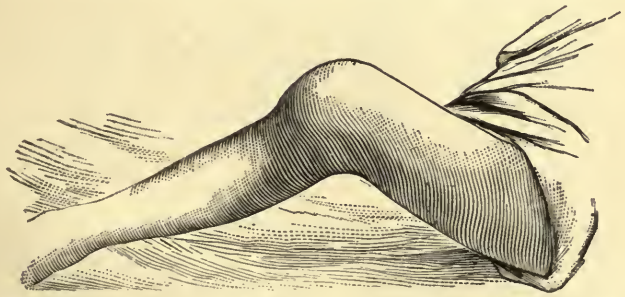

FIG. 86.—TUBERCULAR OSTEOMYELITIS OF BOTH CONDYLES OF FEMUR.

patella. Kummer ("L'extirpation totale de la rotule." *Revue Suisse Rom.*, No. 11, 1889) reports a case of extirpation of the patella for primary tuberculosis of this bone. The patient was 25 years of age, who for three years had suffered from abscess in the region of the patella, followed by permanent fistulous

openings. The patella was extirpated through a longitudinal incision, and, as the synovial membrane on its under surface appeared to be intact, the joint was closed by suturing the ligamentum patella with silk on the one side to the fascia lata, and on the other to the fibrous end of the vastus internus, and the skin was separately closed with sutures. Limb placed upon posterior splint in extended position. Primary union. Restoration of function almost perfect in the course of time. He reports at the same time three similar cases from Kocher's clinic.

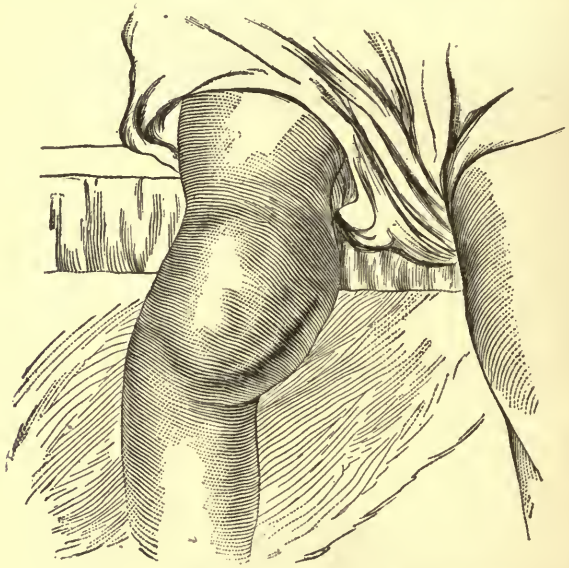

FIG. 87.—CARIES NECROTICA OF TIBIA (DIASTASIS).

In one patient extirpation of patella and bursa of quadriceps, followed by ankylosis. In two cases évidement had to be followed by resection of knee. Three additional cases are reported by Kaufmann. Kummer believes extirpation should be done if disease is limited to bone. Évidement not satisfactory in its results. In many of these cases the disease is located immediately underneath the articular cartilage, and invasion of the joint is an early occurrence. In this joint Kocher asserts he has observed primary tuberculosis of the semilunar cartilages.

Of all joints the knee-joint is best adapted for successful treatment by intra-articular injections, and this method of treatment should receive a fair trial before arthrectomy or resection is undertaken. It can be employed with good prospects of a favorable result in all cases of primary tuberculosis of the synovial membrane, and in secondary tuberculosis of this structure caused by small osseous foci, as long as the disease remains subcutaneous. Large osseous foci caseating or sequestrating, as well as suppurating knee-joints, indicate resection.

RESECTION OF KNEE-JOINT.

History of Operation.—Filkin, of Northwich (*Journ. de Méd.*, vol. lxxxiv, p. 400) resected the knee-joint successfully in 1762, and the patient survived the operation for twenty years. This case, however, did not appear in print until Park, of Liverpool, made the same operation and published an account of his case, in 1782. In the year 1781, Park, of Liverpool, resected the articular extremities of the knee-joint and removed the patella in the case of Hector McCaghen, aged 33, on account of caries of ten years' standing. He made a crucial incision on the fore part of the knee, and found no difficulty in sawing off the ends of the bones. The patient made a tedious recovery, but finally obtained a useful limb. As to the ultimate result, we will let Mr. Park speak for himself: "On the whole, from what I have now seen of this man's limb, I do not hesitate to declare that it appears to me so much more valuable than any artificial one that, was I in his situation, should infinitely prefer the former at the price which he has obtained it." Mr. Park, originator of resection of the knee, with characteristic modesty, insists, in the letter in which he describes his new operation to Mr. Pott, "I am conscious that the mode of operating which I have described is by no means perfect, but still stands in need of the finishing hand of a more able master." Park's case was one of tubercular disease, who recovered so perfectly that he was able to follow the occupation of a sailor.

Moreau made the operation in France in 1792, and Mulder in Holland in 1809. Jaeger performed the operation for the first time in Germany in 1830, and his example was followed by Fricke and Textor. The first operation of this kind in America was performed by Buck in 1844.

Incision.—A crucial incision over the knee was made by Park in his first case. A straight incision over the outer side of the joint was practiced by Chassaignac. A transverse incision below the patella was recommended by Sauson and Begin. Textor modified this incision by giving it a slight curve. Fergusson preferred a straight transverse incision. Two longitudinal incisions, one on the outside and the other on the inside of the patella, were made by Jeffray and Sédillot. Guepratte and Erichsen increased the length and curve of Textor's incision and made an anterior semicircular flap with the convexity directed downward. Moreau connected Sédillot's longitudinal incisions by a transverse cut across the centre of the patella, thus making two flaps,—a method which was adopted by Fergusson and Langenbeck. Jäger made the incision in front across the joint, and after opening the joint made a longitudinal incision as required in each case. Humphrey made a transverse incision, but above the patella. Billroth resorted to a straight, anterior incision over the centre of the patella and sawed the articular ends obliquely, so that the surfaces, on being brought into apposition, would overlap each other.

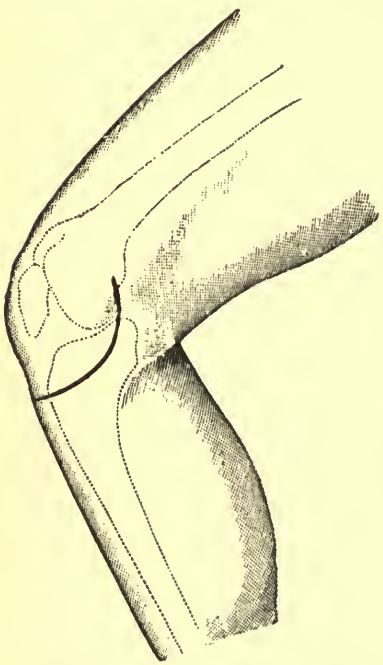

FIG. 88.—ANTERIOR CURVED INCISION. CONVEXITY OF FLAP DIRECTED UPWARD.

Resection and arthrectomy of the knee-joint by an anterior semilunar flap with convexity directed upward and transverse section of the patella are fully described in the chapter on "Resection."

Riedinger's central vertical incision and section of patella in same direction and Volkmann's transverse incision and transverse section of patella are well known, and have been frequently employed both for arthrectomy and excision of the knee-joint.

Modern Operative Technique. — Reinke (Aus der chir. Klinik zu Bonn. "Ueber die Resection des Kniegelenks." Dissertation. Bonn, 1888) gives a description of the method of resection of the knee-joint as devised by Trendelenburg. The incision of the skin extended from one condyle to the other, with the convexity directed upward. A short, longitudinal incision is made to meet the centre of the concavity, and the flaps thus made are dissected up and reflected.

The tendon of the quadriceps is divided transversely, which exposes the fungous capsule freely. If a typical resection is to be made, the condyles are removed and, after division of the tendon of the patella, the tibia is sawn through and capsule with patella and articular extremities removed without further dissection. The bones are brought in apposition and fixed with aseptic ivory nails, and drainage secured and fixation dressing applied. In five years fifty-two resections were made by Trendelenburg by this method. Of this number five died, and in seven cases amputation became necessary later, of which number three proved fatal. Healing by firm ankylosis in extended position without fistulous openings attained forty times; with firm ankylosis, but fistulæ, nine times; without firm ankylosis, three times. Ollier ("Resection du genou." *Lyon Médicale*, 1888, p. 497) in 1888 reported fifty resections of the knee-joint, the whole number done by himself. He recommends that the first dressing should not be changed before the expiration of from forty to fifty days. He uses rubber drains, but believes that in mild cases absorbable drains would answer the purpose. He is of

the opinion that erasion or arthrectomy will only succeed in children; in adults this procedure is followed by local relapses. Neuber ("Ueber Hüft-und Kniegelenk resectionen." *Verh. der Deutschen Gesellschaft f. Chirurgie*, 1884) exposes the patella and knee-joint by an anterior curved incision, with the base directed upward.

The articular ends of the femur and tibia are sawn off, as well as the under surface of the patella. The anterior surface of the lower end of the femur and upper end of tibia are also sawn off sufficiently far so that the space corresponds with the under resected surface of the patella. After extirpation

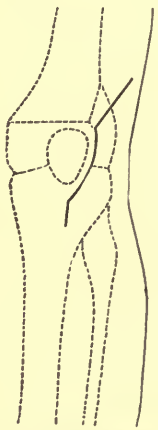

FIG. 89.—OLLIER'S INCISION.

FIG. 90.—MACKENZIE'S ANTERIOR CURVED INCISION.

of the capsule the soft tissues in the popliteal space are stitched to the posterior surface of the tibia and the condyles of the femur. The tibia and femur are brought in apposition and fastened together with two nails. The patella is nailed to the vivified surfaces of the tibia and femur, and the cutaneous flap replaced and sutured. Drainage is established at the most dependent point of the wound by suturing the skin to the deep para-articular tissues.

Hahn ("Ueber Kniegelenksresection." *Verh. der Deutschen Gesellschaft f. Chirurgie*, 1882) renders the limb bloodless with Esmarch's constrictor, and, while it is kept in the extended position, he makes his incision by cutting from a point corresponding with the lowest part of the articulation on the inner side, carrying the knife to the upper margin of the patella and across the limb to a point on the opposite side of the joint where the incision was started. (Fig. 88.) This curved incision, with the convexity directed upward, divides all the structures down to the bone, including, of course, the tendon of the quadriceps muscle. By flexing the leg forcibly the whole of the interior portion of the joint is freely exposed. The synovial membrane is made freely accessible by this incision, and the affected articular extremities can also be thoroughly dealt with. For fixation of the resected ends he uses from two to three steel nails, which are inserted through the skin and driven through the tuberosity of the tibia well into the resected end of the femur.

Whenever it is possible to avoid a typical resection of the knee-joint this should be done, and the removal of tissue limited to the diseased areas. In atypical resection of this joint the chisel is a better instrument than the saw.

The following case illustrates a chisel resection of the knee-joint:—

Tuberculosis of Knee-Joint; Resection; Recovery.—J. H., male, 17 years of age, was admitted into the Milwaukee Hospital, April 5, 1890, with the following history: At the age of 6 he fell from a tree and injured his left knee; some stiffness of the joint remained, but not to such an extent as to inconvenience him much; about one year ago he sustained a second injury to the same knee, which was followed by a painless enlargement of the articulation, except latterly, on walking, but for the past month the pain has been constant. No hereditary history of tuberculosis in his family.

Present Condition.—Patient anæmic; slight rise of temperature at night; pulse small and weak; knee ankylosed and

enlarged, with the point of fluctuation to the inner side of the patellar tendon, which is also the point of greatest tenderness.

Operation.—Vertical incision over the point of fluctuation was followed by the escape of tubercular pus. Digital exploration of the cavity showed that it communicated with the joint, which was opened, by the usual transverse incision, for resection. An atypical chisel resection of the ends of the bones was made, during which three tubercular depots were found in the head of the tibia and one in the inner condyle of the femur. Of those in the head of the tibia, two were situated in the inner half and one in the outer. In the former tubercular necrosis had occurred, and in the latter a triangular sequestrum was surrounded by sclerosed bone. When these had been removed there remained two cavities, each the size of a walnut, that on the inner side being divided into two parts by a septum of sclerosed bone, and extending downward for about one inch and a half into the shaft to opposite the lower angle of the vertical incision; that in the condyle was the size of a hazel-nut. All these were packed with decalcified bone-chips before the bones were brought into apposition; provision was made for drainage by strands of catgut introduced at the angles of the transverse incision and at the lowest point of the vertical; incisions closed by deep sutures of catgut and superficial of silk. On the following day the dressing, having become saturated by sero-sanguineous discharge, was changed. The second change of dressing was made twenty-four days thereafter, when the incisions were found completely healed; the drain opening at the lower angle of the vertical incision was closed by an aseptic blood-clot; the site of the cavity in the head of the tibia was firm on the level of the surrounding bone and painless on pressure; bony consolidation between the resected ends had commenced. The sutures were removed and a light fixation dressing of plaster of Paris applied, which was not removed until complete bony union between resected ends had taken place. Patient has been in good health since. Shortening of limb slight. Walks several

miles daily without any inconvenience, and with only a slight limp.

Direct Fixation of Resected Ends.—In order to obtain bony union in good position and in the shortest possible space of time, surgeons have resorted for some time to direct fixation of the resected ends by suturing or nailing them together.

The objects of this procedure are to secure accurate and

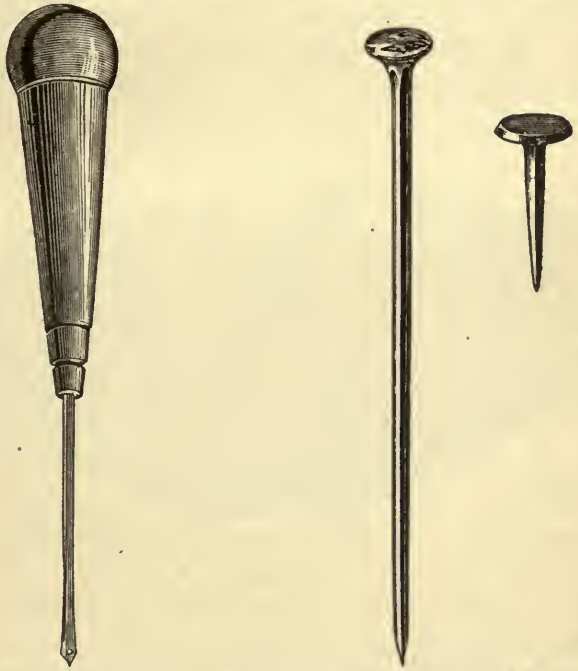

FIG. 91.—DRILL AND BONE-NAILS FOR DIRECT FIXATION OF FRAGMENTS AFTER RESECTION OF THE KNEE-JOINT. (*Bryant.*)

uninterrupted coaptation of the sawn surfaces and to effect perfect immobilization.

The importance of preserving the epiphysial cartilages in resection of the knee-joint in children has been repeatedly referred to. The removal of one or even both epiphysial cartilages of the knee-joint in young children is sure to result in great shortening of the limb. The tibia and femur have been fastened together by nails of iron, steel, ivory, or bone,

which have been driven through the upper end of the tibia deeply into the condyles of the femur. Absorbable nails, such as aseptic bone or ivory nails, have been buried and left permanently in the tissues to be removed by absorption, while metallic nails were left *in situ* until the resected ends were united by a bony callus sufficiently firm to render this mechanical support superfluous.

Morrant Barker ("A Method of Fixing the Bones in the Operation of Excision of the Knee-Joint." *British Medical Journal*, 1887, p. 321) transfixes the upper end of the tibia and the lower end of the femur with two steel needles, which are

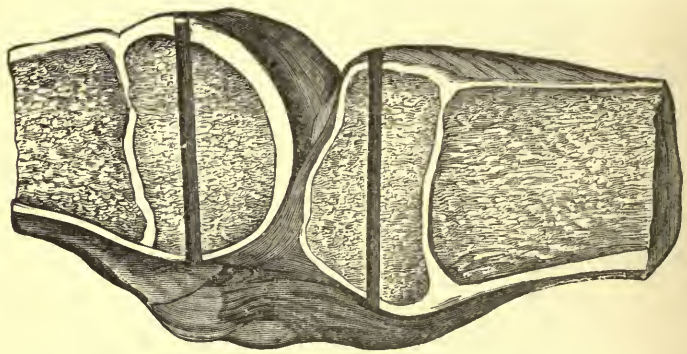

FIG. 92.—EPIPHYSIAL CARTILAGE AND LINE OF SECTION IN EXCISION OF KNEE-JOINT. (*Bryant.*)

made to cross each other in the shape of a St. Andrew's cross. (Fig. 39.)

Willet and Marsh ("Remarks on a Method of Fixing the Bones in the Operation of Excision of the Knee-Joint." *British Medical Journal*, p. 389, 1887) used, for the same purpose, nails made of crocheting needles. Stoker ("On Some Elements of Success in Excision of the Knee-Joint." *Dublin Journal of Medical Science*, July, 1887), Sir William Stokes, Corley, Thomson, and Franks use nails made of strong silver wire, which they remove after three weeks. The use of direct means of fixation of the resected ends in resection of the knee-joint is being gradually abandoned. If the limb is well supported by a circular

plaster-of-Paris splint or a posterior suspension splint, accurate apposition of the sawn surfaces and perfect immobilization of the limb are maintained almost to perfection, rendering the use of fixation nails or sutures unnecessary. The use of proper mechanical support should not be dispensed with until the resected ends have been united by an osseous callus, which will require, according to the age and general condition of the patient, from six weeks to three months.

Ivory Joint.—At the Berlin International Medical Congress, Gluck ("Die Invaginations Methode der Osteo-arthroplastik." *Berl. klin. Wochenschrift*, No. 32, 1890) read a paper and gave several demonstrations of a method of his own device, by which he claims that it is possible to implant successfully, between the resected ends, not only portions of bone, but even whole joints. Among others, he showed a patient whose knee-joint had been excised and an ivory joint inserted. The wound had completely healed, and the patient was capable of flexing and extending the joint through an angle of nearly forty-five degrees without any pain or serious inconvenience. When the ends of the bones have been sawn off in the usual manner, the medullary cavity is scraped out for a certain distance, and a plug of the shape indicated in Fig. 93 is inserted and firmly fixed in its place. It is perforated, so as to allow the surrounding living tissues to find access into its interior. The bone on the opposite side is similarly hollowed out and the same kind of a plug inserted into its interior; the two are then united in such a manner that the two pieces of ivory work upon one another like a hinge. It was generally predicted at the time that the results claimed by Gluck would not turn out favorably in the end. This proved to be the case. In the cases in which the wound healed by primary intention over the foreign body, this was removed later by absorption

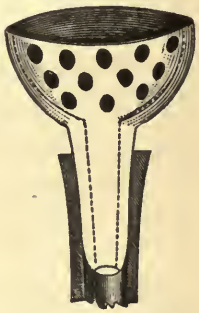

FIG. 93.—GLUCK'S IVORY JOINT.

or gradually found its way to the surface, as has been shown later by von Bergmann. The procedure has even now only an historical interest.

Results.—It is interesting to know something definite of the early results of resection of the knee-joint with an imperfect technique and no antiseptic precautions whatever.

Of the first seventeen cases of resection of the knee-joint made by Filkin, Park, the two Moreaus, Mulder, Fricke, Roux, Textor, Crampton, and Syme between the years 1761 and 1830, and tabulated by Price ("A Description of the Diseased Conditions of the Knee-Joint," etc., p. 58. London, 1865), six were cured and had useful limbs, ten died, and one recovered, but the limb was useless.

Of a later series of nine cases operated on by Jäger, Textor, Lombardo, and Heusser, five were cured with useful limbs, three died from the effects of excision, and one after amputation had been adopted on account of failure of excision of the joint.

Of twenty-one cases of excision of the knee-joint which occurred in the practice of Mr. Fergusson, also quoted by Mr. Price, nine were cured with useful limbs, the degree of utility varying, however, according to circumstances, and eleven died. Taking all of the earlier operations on the Continent and in America, the mortality is nearly 50 per cent.

Sad statistics of knee-joint resections are given by Heineke ("Beiträge zur Kenntniss und Behandlung der, Krankheiten des Knies," p. 240. Danzig, 1866). He reports eleven cases of this operation from the clinic at Greifswald, and of these only four resulted successfully; in the rest the operation proved fatal.

Hornung ("Ueber Resection des Kniegelenks mit einem Falle von doppelseitiger Kniegelenkresection." Dissertation. Würzburg, 1887) informs us of the final result in a case of resection of both knee-joints in the same patient made by Maas. The patient was able to walk and climb hills with great facility. The author gives, at the same time, an account of seventy-one resections of the knee-joint in the clinic at Würzburg, made

during the service of Maas, from 1877 to 1886. Subsequent treatment by amputation became necessary in thirteen cases.

Ollier ("Sur la resection du Genou." *Bull. de l'Academie*, No. 20, 1889) calls attention, in this paper, to the fact that resection of the knee-joint is not popular in France at the present time, as some surgeons in that country do not resort to it even now. He performed the operation up to the year 1870 seventeen times, and all patients but one died. Since the introduction of antiseptic surgery his mortality has been reduced to 10 per cent. He has now performed the operation fifty-six times, and in the last series of thirty consecutive cases since 1866 only three deaths occurred, and of these only one was caused by the operation (shock). The remaining two deaths supervened sixty-three days and seven months after the operation. Since 1884 he applies only one dressing, which is allowed to remain from forty to fifty days, when bony consolidation was found complete. He uses Neuber's drains, and sutures the wound. He advises the use of a fixation dressing until bony union is sufficiently firm to support the weight of the body and to prevent angular deformity.

Hitzegrad ("Mittheilungen aus der chirurgischen Klinik zu Kiel," B. iv) gives us the final results after resection of the knee-joint done at Kiel since the introduction of the antiseptic method of treating wounds and the elastic tourniquet. From the results obtained in 115 cases of complete or typical resection of this joint, the author comes to the conclusion that resection should be upheld, when done antiseptically and with the Esmarch bandage. Seventy-three per cent. of the severe cases were cured in an average of eighty-five days, and 21 per cent. of the patients dismissed as more or less completely cured had a good use of the limb after five years and a half. Of Boeckel's 58 cases, 55 were cured and 3 died. Of 47 typical resections, 44 recovered and 3 died. In the remaining cases arthrectomy was made, and all of these recovered. Of the 44 cases of typical resection which recovered from the operation, 3 were subjected later to

amputation, and in 4 the resected ends did not unite by bony callus. In 37, bony consolidation was obtained. The time required to effect firm union varied from seventeen to fifty-six days, but in 2 cases it required two and seven months.

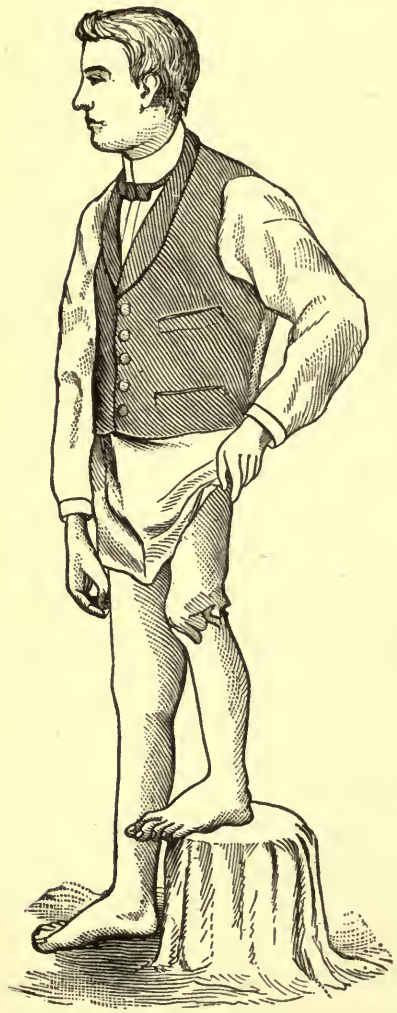

FIG. 94.—SHORTENING OF LIMB AFTER COMPLETE RESECTION OF THE KNEE-JOINT, WITH REMOVAL OF BOTH EPIPHYSIAL CARTILAGES. (*Pemberton's case.*)

Zoege-Manteuffel ("Ueber die Behandlung fungöser Kniegelenkentzündung mittels Resection. *Deutsche Zeitschrift f. Chirurgie*, B. xxix, p. 113) gives an interesting and valuable account of fifty-five resections of the knee-joint, made in the clinic at Dorpat during the last ten years. Only in two of these cases was the disease limited to the synovial membrane; in all the rest of the cases the disease had an osseous origin, and the embolic form appeared to predominate. On this account many of the patients died later from other tubercular affections. The resected ends were fastened together by two strong silk sutures, one on each side. In forty-seven of these cases the healing process required from eight months to two years. Primary healing of wound occurred thirty-nine times. Six deaths, of which one was caused by carbolic-acid intoxication, four died of general tuberculosis, and one of fat embolism.

As to shortening, it is necessary to distinguish between cases where the epiphysial line is preserved and where it is not. Hoffa (*Archiv f. klin. Chirurgie*, B. xxxii, Heft 4) observed that, in the cases which he reported from the clinic in Würzburg, the removal of both epiphysial lines in children show that at the end of ten years the shortening may amount to twenty-five and one-half centimetres, while in another case it amounted in two years to ten centimetres.

The shortening, in most of the cases, corresponded to the time elapsed. Where only one epiphysial line is destroyed, there is still shortening, though less. Loss of the femoral line showed seventeen centimetres shortening in six years, and seven centimetres in one and one-half years. Two cases of like duration, affecting the tibial line, showed fifteen and one-half and six centimetres, respectively. The cases in which the epiphysial lines are preserved do not show a gradually increasing shortening as strongly as when the epiphysial cartilages are included in the resection. It amounted, in one of Hoffa's cases, at the end of six years, to thirteen and one-half centimetres; in others, even older cases, it was much less, and up to the end of two years it never exceeded five centimetres. To save the epiphysial line, König's rule is valuable: "Saw off inside the extent of the cartilage." After this, any remaining morbid deposit must be scraped and chiseled out. (Fig. 92.) Cavities made on the surface of the resected ends should be packed with chips of decalcified, iodoformized bone, as was done in the following case:—

Tuberculosis of Knee-Joint; Resection; Recovery, with Useful Ankylosed Limb.—M. L., a strong, healthy-appearing female, 26 years of age, with no family history of tuberculosis, has for the past eight years suffered from knee-joint trouble. One year ago a layman undertook to effect a cure. This treatment was followed by an acute synovitis, which, after four months' rest in bed, subsided so that the patient was able to get around again. A second attack occurred during the past

winter, which left the knee permanently enlarged. Since March she has been walking on crutches. On admission to the hospital, November 5, 1889, there was found fibrous ankylosis of the knee, uniform enlargement of the joint, which, to the examining finger, felt firm. No glandular enlargements in the groin.

Operation.—Complete resection of the knee-joint, patella included. On section of the tibia, the bone was found highly osteoporotic, and in the inner tuberosity a triangular sequestrum surrounded by granulation tissue and incased by sclerosed bone. Corresponding to this, there was present a caseous depot in the inner condyle of the femur. Both these were eliminated, and there remained in the condyle a cavity the size of a pigeon's egg, and in the tibia one of half that size. After complete extirpation of the capsule, thorough iodoformization of the wound and ignipuncture of the tibia, both cavities were firmly packed with decalcified bone-chips before bringing the resected ends into apposition. A catgut drain was introduced at either angle of the incision, which was closed by deep sutures of catgut and superficial of silk. The quadriceps and patellar tendons were united by a strong catgut suture. A copious antiseptic dressing was applied and retained by a plaster-of-Paris bandage, in which was incorporated a posterior iron splint extending from the middle of the thigh to the toes. The limb was kept in an elevated position for two weeks. The highest temperature, 101.5° F., was reached the evening of the second day; the following morning it was reduced to 99° F. No rise in temperature after this date. At first dressing, on the sixteenth day, the incision had completely healed, except at the points of drainage; sutures removed and plaster-of-Paris dressing re-applied. Twelve days later the dressing was removed and the incision found completely healed. Examination at the end of the sixth week showed consolidation well advanced, with only three-quarters of an inch shortening; fixation dressings were dispensed with twelve weeks after operation, and the patient ordered to walk

on crutches. This she refused to do until two weeks later, when, to her surprise, she could bear her weight on the limb without any pain or inconvenience.

Arthrectomy.—Arthrectomy or, better, synovectomy was first performed for tuberculosis of the knee-joint. In primary tuberculosis of the synovial membrane this is the operation *par excellence.* Anatomically, the knee-joint presents the most favorable conditions for this operation; from a pathological point it is not often indicated, as primary synovial tuberculosis of this joint is much less frequent than the osseous form. Arthrectomy and atypical resection combined are the procedures most frequently applicable, as extirpation of the capsule must always be combined with the intra-articular removal of osseous foci in the condyles of the femur or head of tibia.

Volkmann ("Die Arthrectomie am Knie." *Centralblatt f. Chirurgie*, No. 9, 1885) urged the substitution of extirpation of the synovial sac for typical resection, on account of the bad functional results—shortening and angular deformity—which so often follow the latter operation. He commences the operation by making a short transverse incision, and opening the joint for inspection and digital exploration. If, upon such examination, a complete arthrectomy is deemed necessary, he divides the patella transversely. If the upper recess is much affected, he advises the formation of a flap with base directed upward, in order to secure a more free access to the joint. He does not use Esmarch's constrictor, as he claims that in bloodless operations it is not as easy to distinguish between healthy and diseased tissue. He places great stress upon the thoroughness with which the operation should be done. Osseous foci are attacked from the articular surfaces of the bone. By this operation joints are often ankylosed, but the limbs are useful and not shortened.

Mandry ("Zur Frage der Arthrectomie des Kniegelenks bei Kindern." Bruns' *Beiträge zur klinischen Chirurgie*, iii, Heft 2, 1887) reports seven cases of arthrectomy of knee-joint for tuberculosis in children. In six of these cases, recovery,

as far as the operation-wound was concerned, was completed in from four to six weeks, and the function of the joint was restored almost to perfection in one of the cases; in the rest, ankylosis. In one case resection had to be done as a secondary operation. In four cases there was no shortening, or, if it was present it was very slight, while in the two remaining cases the limb was actually from one to one and a half centimetres longer. The author collected sixty-three cases from other sources in which the operations were done for the removal of the diseased synovial membrane, and with the utmost care to avoid removal of cartilage and bone-tissue. This made the whole number of cases of arthrectomy of the knee-joint, upon which the author bases his remarks on this operation, seventy. Of this number seven died: two of pulmonary tuberculosis, one each of iodoform intoxication, chloroform asphyxia, general tuberculosis, tubercular peritonitis, and tubercular meningitis. The operation proved a failure in nineteen cases, as it was followed by return of the disease, which was treated by secondary resection six times, with three successes and three failures; in the latter amputation became necessary; in one case amputation was performed after the arthrectomy. In forty-four cases the result was satisfactory. In none of these cases could shortening, to any degree, be detected. On the other hand, in three, measurement of the limb showed an elongation of the limb from one to one and a half centimetres. The author attributes the elongation to removal by the operation of the intra-articular pressure. A movable joint was obtained in eight cases, ankylosis thirty-two times; flail-joint was never observed. Contracture of the joint followed in a number of cases, which should remind the surgeon again not to remove immobilization splints too early. A movable joint was obtained in several of my cases, even when a small osseous focus had to be removed at the same time, of which the following case furnishes a good illustration:—

Tuberculosis of Knee-Joint; Arthrectomy; Recovery, with Good Motion of Joint.—E. K., 4½ years of age, child of healthy

parents, and with no family history of tuberculosis, admitted to the Milwaukee Hospital March 10, 1890, for an affection of the knee-joint, which developed after an injury six months ago. At present the joint is uniformly enlarged, painless and doughy on palpation. A typical arthrectomy was made on the same day and the primary depot of infection found in the intra-condyloid notch, where limited sequestration had occurred. When this depot was removed there remained a cavity the size of a hazel-nut, which was packed with decalcified bone-chips. Recovery was retarded by an acute attack of catarrhal icterus, which developed the second day after the operation and lasted about a week. Some suppuration occurred in the superficial incision, which had completely healed by the end of the twelfth week. No shortening of limb. Motion in joint at first limited, but gradually increased by active and passive motion and massage.

Israel ("Zwei Fälle von Arthrectomia synovialis des Kniegelenks mit erhaltener Beweglichkeit." *Berl. klin. Wochenschrift*, No. 5, 1889) reports two cases of synovial arthrectomy of the knee-joint in patients, aged respectively 39 and 11 years, with excellent functional results. In the first case the knee-joint was opened by a vertical incision through the patella; in the second case the interior of the joint was made accessible by sawing through the tuberosity of the tibia in an upward and backward direction, after which the wedge-shaped piece of bone with the tendon of the patella attached was reflected in an upward direction. After extirpation of the diseased parts, the piece of bone, temporarily resected, was replaced and fastened with a nail. In this case not only the synovial membrane, but the entire capsule, crucial ligament, and semilunar cartilages were removed, and yet the functional result was excellent, the patient being able to flex the leg at a right angle with the thigh. When the synovial membrane back of the joint is also affected Zesas (*Centralblatt f. Chirurgie*, No. 28, 1886) advises that the large popliteal vessels should be laid bare as far as the

granulation masses extend; they can then be held aside until all the diseased tissue has been thoroughly removed. In very bad cases the vessels are to be approached from the popliteal space, and then drawn back out of the way until the capsule has been removed. In several cases of arthrectomy of the knee-joint in young adults, where I had to remove the entire capsule, the patients recovered with limited motion of the joint.

CHAPTER XXXVII.

Tuberculosis of Ankle-Joint and Tarsus.

Tuberculosis of the ankle-joint and tarsus have much in common, as the disease is very prone to extend from the former to the latter, and *vice versâ*, while the etiological factors in the causation of the disease in both localities are identical.

Primary Location of Disease.—Tuberculosis of the foot occurs most frequently in the parts which transmit the weight of the body to the ground, namely, the ankle-joint, os calcis, head of astragalus, the tarsal bones, and the proximate end of the first metatarsal bone.

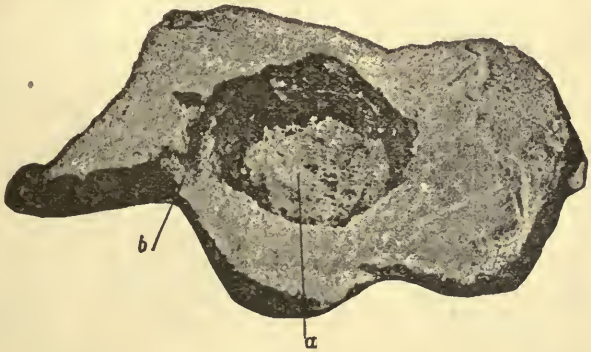

Fig. 95.—Sagittal Section of Os Calcis. Natural size. (*Krause.*)

a, in the middle of the bone a large cheesy sequestrum; *b*, perforation toward surface in the form of a cloaca.

Münch states that in 28 cases, where the ankle-joint alone was affected, the disease was primarily synovial in 23, the lower end of the tibia in 1, and the astragalus in 4. Erasmus, on the other hand, found in 11 cases that only 2 were primarily synovial, in 3 sequestra were present, and in 6 there were caseous deposits in one of the articulating bones.

Cheyne is of the opinion that in the ankle-joint primary synovial disease is much more common than primary osseous disease, and that the osseous form begins most frequently in the astragalus, and next in frequency comes the upper part of the

malleoli. Czerny found, in fifty-two cases, that the astragalus was affected fifteen times, the os calcis thirteen, the cuboid sixteen, the scaphoid and cuneiform eight.

Treatment by iodoform injections in tuberculosis of the ankle deserves a faithful trial, although the results are not as favorable as in the treatment of the same affections of the knee-joint. As extension of this joint is not applicable, the remaining conservative treatment must consist in immobilization, which is done most efficiently by applying a plaster-of-Paris boot reaching from the toes to the knee-joint,

FIG. 96.—TUBERCULAR OSTEOMYELITIS OF ASTRAGALUS.

FIG. 97.—FUNGOUS SYNOVITIS OF ANKLE-JOINT.

interposing a thick layer of aseptic hygroscopic cotton to prevent decubitis over bony prominences.

RESECTION OF ANKLE-JOINT.

History of Operation.—The technique of resection of the ankle-joint has undergone many radical changes since this operation was first practiced. Resection of the ankle-joint for compound fracture has been practiced since 1792 by Rumsey, Read, Weber, and Sédillot, but the first operation for disease of this joint was made by Moreau in 1792. Champion per-

formed the operation in 1813, Roux in 1832, Jäger in 1833, Textor in 1844, Heyfelder in 1845, Wakley in 1847, and Hussey in 1858.

Incision.—Chassaignac recommended a single, straight, external incision. Bourgerie made two incisions, one on each side, three to four inches in length, parallel with the tibia and fibula, each terminating a little below the respective malleolus. Moreau advises two incisions, three inches or more in length, along the posterior edge of the tibia and fibula, from their inferior extremities upward, and then two transverse cuts from the lower ends of these, in a direction forward, as far as the tendon of the tibialis anticus on the tibial, and that of the peroneus tertius on the fibular side. The flaps thus formed having been raised, the bones of the leg are exposed and divided, by means of the saw or pliers, as high as may seem necessary, after which the separation of the ligamentous connection is easily effected. Jäger made the transverse cuts a little longer, and, if necessary, on each side of the long cut. Velpeau and Guepratte gave to the lower end of the long incisions a semilunar shape by following the margins of the malleoli forward.

J. F. Heyfelder and Sédillot opened the joint freely in front by a transverse incision, which also severed the extensor tendons, while Hussey made a semilunar flap on the same side with the base directed upward.

O. Heyfelder does not believe that it is necessary to divide the extensor tendons, which he claims can be held out of place by retractors during the removal of the joint.

A posterior transverse incision with division of the tendo Achillis was practiced by Wakley and Textor. Pelikan divided the tibia and astragalus obliquely, so that the sawn surfaces should overlap each other.

Modern Operation.—About thirty-five kinds of incisions have been devised by different surgeons for resection of the ankle-joint, which show conclusively that none of them fully answer the purpose. It is impossible to devise any one incision

that will be applicable to all cases. Special indications call for different incisions. The incisions which will be described in the next section of this chapter will be found useful in different cases. The existence of fistulous openings will often determine the kind of incision which it is necessary to make to gain access to the joint, and enable the surgeon to remove all of the infected tissues without injuring important para-articular structures.

Textor (Osann, "Ueber die Resection des Fussgelenks."

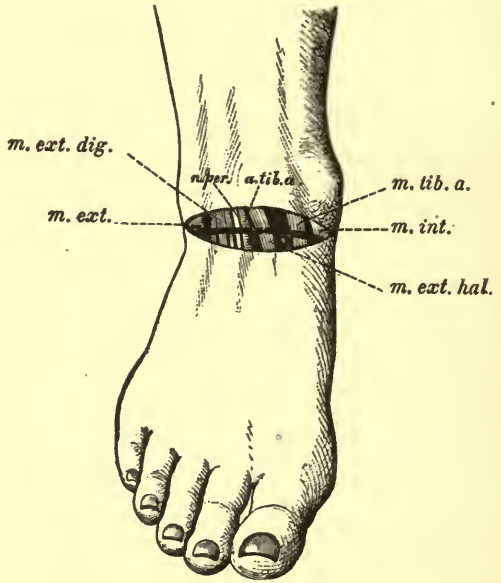

FIG. 98.—HUETER'S ANTERIOR INCISION.

m. ext., external malleolus; *m. int.*, internal malleolus; *m. tib. a*, anterior tibial muscle; *m. ext. hal.*, extensor muscle of toe; *a. tib. a.*, anterior tibial artery; *n. per.*, peroneal nerve; *m. ext. dig.*, extensor muscles of toes.

Würzburg, 1853) makes a posterior transverse incision from the middle of the posterior border of one malleolus to a corresponding point on the opposite side, which divides also the tendo Achillis. Before the tendon is divided the upper portion is fixed in a loop, so that it can be readily found when wanted. The deep fascia is carefully divided upon a grooved director in order to avoid injury to the important vessels and nerves. The joint is then opened by a longitudinal incision parallel to the middle

of the tendo Achillis. If necessary, the lateral ligaments are divided with a blunt-pointed bistoury, and the diseased bones and capsule removed with chisel, sharp spoon, and scissors. The tendo Achillis is separately sutured before the external wound is united.

Hueter ("Ueber Resection des Fussgelenks mit vorderem Querschnitt." *Archiv f. klin. Chirurgie*, B. xxvi, S. 812) observed so many relapses in his operations on the ankle-joint for tubercular affections by Langenbeck's method that he devised a more direct route into the joint.

He makes an anterior transverse incision by cutting from the posterior border of the internal malleolus around the tip and across the ankle in front, to a point on the posterior margin of the external malleolus corresponding with a point opposite, where the incision was commenced on the inner side. The superficial peroneal is divided by the incision. After dividing carefully the deep fascia, the operator looks for the tendon of the anterior tibial muscle, which is transfixed with a strong catgut thread, to which the needle remains attached. The tendon of the extensor pollicis is dealt with in the same manner. By making traction on both catgut threads the tendons are separated sufficiently to find the anterior tibial artery, which is divided between two ligatures. The veins are similarly ligated and divided. The nervus peroneus profundus is divided as well as the tendons of the extensor communis, which is also fixed with a ligature and cut below. The anterior wall of the capsule of the joint is now divided transversely, and, while the foot is strongly flexed toward plantar surface, the talo-fibular, calcano-fibular on the outer side, and the deltoid ligament on inner side are put on the stretch and divided. The necessary removal of diseased tissue, synovial and osseous, can now be done with ease. After the resection the divided muscles and nerve are sutured. Two transverse drains are inserted and the external wound closed.

König's ("Ueber die Operationsmethode des Verfassers bei

Tuberculose des Tibio-Tarsal und des Talo-Tarsalgelenkes." *Archiv f. klin. Chirurgie*, Bd. xxxii) operation is based upon the apparent necessity of exposing freely the synovial sac upon the anterior aspect of the joint.

Two incisions are made over the anterior aspect of the joint which include the anterior portion of the capsule. The principal incision, the inner, is made over the anterior aspect of the tibia, commencing about three centimetres above the joint, and is made to curve along the anterior border of the internal malleolus, and as soon as the joint is reached the incision is made into the joint, down to the neck of the astragalus, and is terminated at the junction of the astragalus with the scaphoid. The incision opposite to this one is made along the anterior border of the fibula, into the joint, and terminating again at the scaphoid. The bridge of soft tissues over the ankle-joint lying between these incisions is carefully separated with forceps, elevator, and knife, from the anterior capsule of the joint, sufficiently far so that it can be lifted away from the joint far enough to enable the free removal of the capsule. If resection becomes necessary, this operation is commenced by cutting with a chisel through the base of the malleoli in such a manner that the external cortical layer is not cut, but is fractured, and the malleoli are turned outward. Injury to tendons can always be avoided by observing ordinary care.

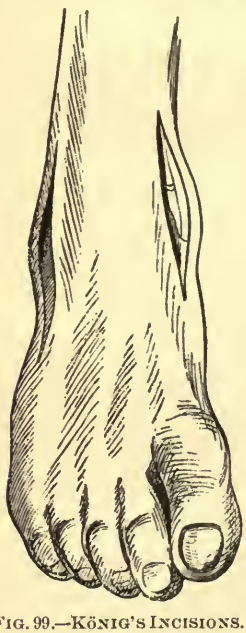

FIG. 99.—KÖNIG'S INCISIONS.

After elevating the flap a wide chisel is used in cutting off the lower end of the tibia. The removal of the disk of bone is sometimes quite difficult, but can always be accomplished. The upper surface of the astragalus is now well exposed. Unless special indications are present, only the upper surface

is removed with the chisel. If the whole bone is affected, or if disease has extended to joint between it and calcaneus, the whole bone is extirpated. The synovial membrane must be thoroughly extirpated with dissecting forceps and scissors. The most difficult part to remove is the posterior duplicature of the capsule, extending from the posterior margin of the tibia to the talus; this part of the operation is greatly facilitated by extension and flexion of the foot. After disinfection and iodoformization of the joint a drain is inserted into each lower angle of the wounds, and the balance is sutured. The foot maintains now its own position, especially if what remain of the malleoli is pressed toward the joint. A copious Lister dressing is applied, and the limb placed in an elevated position for at least twelve hours. After the wounds have healed, no apparatus is required to prevent deformity, as the foot is kept in normal position without any mechanical support.

Ebert ("Ueber Resection des Talo-cruralgelenkes mit dorsalem Lappenschnitt." Dissertation. Greifswald, 1889) describes Helferich's new operation for resection of the ankle-joint and reports three cases operated upon by this method. The ankle-joint is exposed anteriorly after the reflection of a short dorsal flap. A transverse incision is made across the dorsum of the foot down to the bone at a point or a little above Lisfranc's joint, and from the ends of this incision another incision is made on each side of the malleoli. The flap, including fascia, tendons, nerves, and vessels, is detached from the bones and reflected upward; while the foot is forcibly extended the malleoli on each side are cleared and the lower end of the tibia and fibula resected. After this, as much of the tarsal bones as may appear necessary is removed, and, if required, a portion of the ends of the metatarsal bones. If ankylosis appear desirable, bone sutures are advised. Tendons are not sutured. The healing and functional result in the three cases were satisfactory.

Schmidt ("Vorderer und hinterer Längschnitt zur Ausführung der Arthrectomia synovialis am Talocruralgelenk."

Centralblatt f. Chirurgie, No. 2, 1889), of Cuxhaven, reasoning from the fact that the capsule of the ankle-joint is much longer in front and behind the joint than on the sides, recommends to expose this joint in making arthrectomy by an incision in front and behind. He makes the posterior incision about six centimetres in length, close to and in the course of the tendo Achillis down to the prominence of the os calcis, dividing the skin, fascia, and subfascial fat. The margins of the wound are now retracted, when the bulging capsule comes in sight, resembling somewhat in appearance a lipomatous, hernial sac. After incision the capsule prolapses more, and is easily extirpated with forceps and scissors. The joint is now freely opened and can be explored with the finger. The anterior incision is made in the same manner as has been advised by Vogt, vertical, and at a point about the middle between the malleoli, which exposes the important vessels and nerves in this region. The tendons of the extensor pollicis are drawn toward the inner side with blunt hooks. The anterior recess of the joint is now reached and incised, when the capsule is thoroughly extirpated, after which the interior of the joint can be easily inspected and diseased tissue removed. Should it become necessary to remove osseous foci, Kocher's lateral incision can be added, which would then afford an abundance of room.

According to Paulsen ("Ueber Arthrectomie des Fussgelenkes mit temporärer extirpation des Talus." *Centralblatt f. Chirurgie*, No. 31, 1889), it is always necessary to remove the talus in making an arthrectomy of the ankle-joint, otherwise it is impossible to inspect the articular surface of the tibia and the space between the articular extremity of this bone and the fibula. It is also a common condition to find, during the operation, that the disease has extended to the talo-tarsal joint. Iverson opens the ankle-joint by a curved anterior incision, and removes the astragalus. Functional results good. As the astragalus in several cases showed no signs of disease, Paulsen suggests that this bone might perhaps be replaced after the

completion of the arthrectomy. This was done successfully in a child 7 years of age.

Busch ("Eine neue Methode zur Resection oder dem Évidement des Fussgelenkes bei fungöser Entzündung." *Centralblatt f. Chirurgie*, No. 41, 1882) has devised an incision by which the ankle-joint is freely exposed by an osteoplastic resection of the os calcis. He carries the incision from the external surface of one malleolus to the other by cutting down and across as far as the sole of the foot, and in front of the tuberosity of the os calcis, then curving slightly backward and upward to the external malleolus to a point opposite to where the incision was started. The tendons, vessels, and nerves are carefully avoided, but as soon as the os calcis is reached the cut is made to the bone. The tendons, vessels, and nerves in the groove behind the malleolus on each side are carefully lifted out with an elevator, and kept out of the way with retractors, while the os calcis is sawn from the anterior border of the tuberosity in an oblique direction upward and backward, toward the posterior articular surface of the astragalus. After dividing the posterior wall of the capsule, the ankle is freely opened. If necessary, the astragalus can be removed, and osseous foci in the lower end of the tibia and fibula can now be removed. If the os calcis is healthy, the bone is replaced after complete removal of the synovial membrane, and united with two metallic sutures.

Schmid-Monnard ("Ueber Pathologie und Prognose der Gelenktuberculose, insbesondere des Fusses." Kiel, 1888) reports nine cases of resection of the ankle-joint for tuberculosis from Neuber's clinic. One patient succumbed to intestinal tuberculosis twenty-two months after the operation; the remaining number recovered, and remained well two and a half to three and three-quarter years after operation,—the time the report was made. The functional result in six was excellent, and in two fair. He has collected ninety-two cases of resection of the ankle-joint for tuberculosis, of which number 70.6 per cent.

healed without recurrence to 29.4 per cent. in which the result was not favorable. Consequently, about 25 per cent. of all resections of this joint remain unhealed locally, in spite of subsequent amputation, which, at times, had to be resorted to after resection proved a failure. He recommends Hueter's transverse dorsal incision. The transverse incision (Bardenheuer) through the extensor tendons affords ample space in the operative treatment of the deeper affections of the anterior tarsal region, but the final result is often unsatisfactory, on account of adhesions of the severed tendons to the skin and cicatrix, and, consequently, impaired motion of the toes. To prevent this, Studsgaard (*Centralblatt f. Chirurgie*, No. 43, 1890) recommends a longitudinal incision. He splits the foot from before backward between second and third toes, cutting through the ligamenta tarso-metatarsea and opening the capsule between the middle and external cuneiform bones. First and second toes, with their cuneiform bones, may now be moved inward; third, fourth, and fifth toes, with the external cuneiform and the cuboid bones, outward, and the tarsus widely opened. It is now very easy to remove the diseased bones and soft tissues, and then suture the wound along the dorsum and planta of the foot, leaving a drain through the foot in the posterior angle. The only tendon severed is that of the peroneus longus, which crosses the incision in the planta on its way to the cuneiform bones and the bases of first and second metatarsal bones. No large arteries or nerves are severed. The author reports a case in which the result was very satisfactory.

Albanese ("Sulla resezione dell articolazione tibio-tarsica." Dissertation, 1869) makes an outer incision slightly curved, nine to ten centimetres in length, extending from a point seven centimetres above the tip of the external malleolus to the cuboid bone, and divides in one stroke of the knife all the soft tissues. The dislocation of the joint is easily affected after division of the external lateral and interosseous ligaments. He reports three cases operated on by this method, two of which proved

successful; in the third, Syme's amputation had to be performed one year later, for return of the disease.

Lauenstein ("Ein einfacher Weg, das Fussgelenk freizulegen." *Arch. f. klin. Chirurgie*, B. xl, Heft 4) makes the statement that not less than thirty-three methods of resecting this joint have been devised. His method consists in doing as little violence to the important soft tissues surrounding the joint as possible, and yet securing free access to the joint.

Fig. 100 shows the location and extent of the external

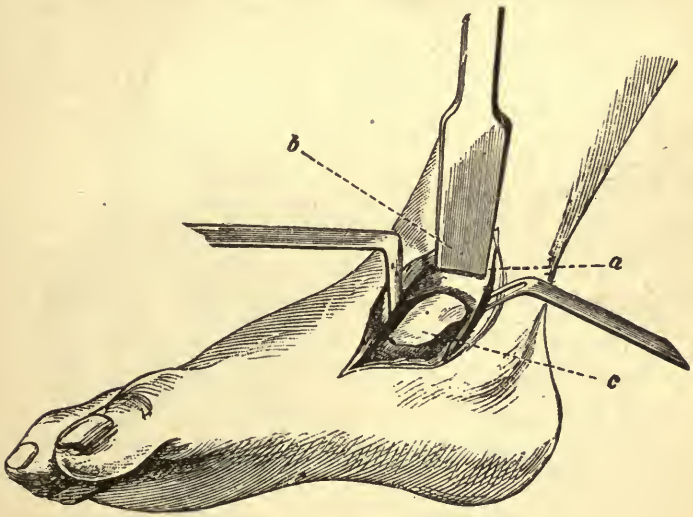

FIG. 100.—LAUENSTEIN'S OPERATION. EXTERNAL INCISION.

incision. The soft tissues on each side of the lower end of the fibula are carefully separated, and after division of the ligament on the outside, in front and behind the joint, the talus is dislocated by placing the foot in equinus position and rotating it inward. The joint is now freely exposed, as may be seen from Fig. 101, and, while the soft tissues are kept out of the way by blunt retractors, the arthrectomy or resection can be readily made.

The functional result after a successful resection of the ankle-joint is usually satisfactory, and often almost perfect. The

following case, that came under my observation, is here inserted to illustrate this point:—

Tuberculosis of Ankle-Joint; Resection; Almost Perfect Functional Result.—W. C., male, 19 years of age, was admitted into the Milwaukee Hospital, January 21, 1890, with the following history: Father died of asthma, and two sisters of phthisis pulmonalis. At the age of 7 the patient had measles, followed by sore eyes for a period of three years; as the eyes improved, trouble developed in the left ankle, which compelled him to use crutches for three years more. He continued well until about

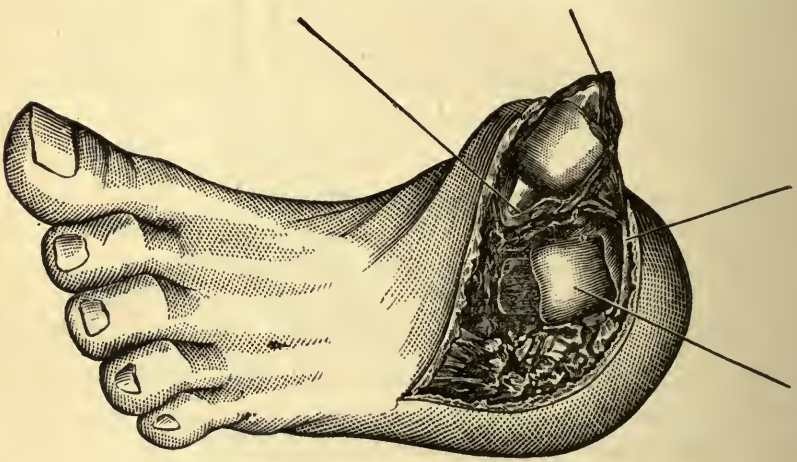

FIG. 101.—LAUENSTEIN'S OPERATION. DEEP DISSECTION.

four months ago, when the same ankle began to swell; no pain at any time except when stepping hard on the heel.

Present Condition.—Patient very anæmic, ankle ankylosed and enlarged, no fluctuation, swelling most marked behind the external malleolus, thickening of the lower end of the tibia.

Operation.—Chisel resection of the malleolus externus and articular surface of the tibia, and complete removal of the astragalus through a linear incision behind the external malleolus. The primary depots were found to be in the tibia, from which the disease had extended to the articulation and the astragalus. After removal of these depots two cavities remained, one the

size of a marble and the other half that size. These were filled with decalcified bone-chips and the bones brought into apposition; incision closed; foot placed on a rectangular splint and retained by plaster-of-Paris splint. On the third day a change of dressing was necessitated because of saturation with bloody serum. Seventeen days subsequently the sutures were removed; union complete, except at the points of drainage. With the exception of the formation of a small connective-tissue abscess on the inner side of the tendo Achillis, recovery was uninterrupted; patient walked on crutches at the end of the second month, and left the hospital two weeks later greatly improved in general health, with good motion of the ankle-joint. The ultimate functional result in this case was almost perfect.

Arthrectomy.—The anatomical structure and the surroundings of this joint are not well adapted for arthrectomy without removal of some of the bony structures which enter into the formation of the joint. It has, therefore, been found difficult to devise incisions which would enable the surgeon to extirpate the soft structures of the joint without interfering with the articular ends. One of the best incisions, so far devised, for reaching every portion of the ankle-joint without injury to important soft parts and without implicating the bony structures, is the one described by Kocher (*Archiv f. klinische Chirurgie*, B. xxxiv, Heft 2) in 1883. The foot being held at its normal right angle, an incision is made from the tendo Achillis, with a slight downward curve over the tip of the external malleolus to the extensor tendons. After dividing skin and fascia, the peroneal tendons are exposed, tied with two loops, and divided between. This last cut also opens the external portion of the ankle-joint. The ligament attachments to talus and calcaneus are then severed, and the joint-capsule dissected from the anterior and posterior side of the tibial joint-surface as far toward the internal malleolus as possible. The foot can now be readily dislocated inward, care being taken not to break off the tip of the internal malleolus. In this position of the foot the whole of

the interior of the joint is freely exposed. After excision of the diseased parts the foot is again brought into its normal position, and the tendons are sutured. The wound is now closed and dressed in the usual manner. This method closely resembles that of Reverdin, except that the latter also divides the tendo Achillis and does not suture the peroneal tendons. The results in five cases of tuberculosis of the ankle-joint, operated on by this method, were excellent.

Reverdin's (French Surgical Congress, 1885) method of incising the ankle-joint for the removal of tubercular products permits the operator to decide, when he has opened the ankle-joint, to what extent he will remove the parts. His incision extends from the edge of the tendo Achillis forward, and almost horizontally beneath the external malleolus, as far as the insertion of the peronei. He has devised a light form of forceps with which to seize and extract the astragalus. When that bone has been removed he examines carefully the parts left, and if he finds it necessary, for the complete examination of the joint or removal of the disease, he divides the tendo Achillis. Or, on the other hand, he can now change the operation into an amputation of the foot with an internal plantar flap. He has found no inconvenience to follow division of the tendo Achillis.

Girard ("Ueber die Arthrectomie des Fussgelenkes." *Correspondenzblatt f. Schweizer Aerzte*, p. 19, 1887) claims that incision of the capsule in operations upon joints leaves the joint in a weakened, imperfect condition, and he has, therefore, devised an osteoplastic operation in gaining access to the ankle-joint.

The limb resting on the internal surface, a horizontal incision is made over the outer aspect of the ankle-joint, at a point corresponding with the line of the joint, beginning at the outer margin of the tendo Achillis and terminating at the extensor muscles of the foot, dividing all the tissues down to the bone, including the tendons of the peroneal muscles. The external malleolus is now cut through with knife or chisel, at a point

corresponding with the horizontal fissure of the joint. If the joint has been rendered loose by the disease, it is now easy to turn the foot inward sufficiently to expose fully its interior; if this is not the case a vertical incision is made through the soft tissues, along the anterior border of the external malleolus. After extirpation of the capsule the divided tendons are sutured and the external malleolus is carefully replaced, and retention secured by suturing with catgut. The joint is completely closed by introducing a suture in front and behind the malleolus.

Bruns (*Münch. Med. Wochenschrift*, No. 24, 1891) has recently described a new method of performing arthrectomy of

FIG. 102.—GIRARD'S METHOD OF EXCISION OF THE ANKLE-JOINT.

the ankle-joint. This is the latest addition of about thirty-five methods that have been devised by different surgeons for the operative removal of diseased tissue from this joint. This operation is intended to furnish the best access to the joint not only for the purpose of removing osseous foci, but also the diseased soft structures of the joint. It is a modification of König's operation, which consists in two long anterior incisions. It exposes the anterior synovial sac, and permits of removal of this membrane and of the articular ends of tibia and astragalus; but the posterior portion of the joint remains inaccessible, and the soft structures in this part of the joint cannot be extirpated unless the entire astragalus is removed. To the two anterior

incisions Bruns adds two posterior, carrying one along the inner, the other along the outer, edge of the tendo Achillis. The anterior incisions are commenced about four centimetres above the joint, and carried downward in front of the corresponding malleolus as far as the medio-tarsal joint. The intervening portion of soft structures having been separated from the bones, the anterior synovial sac is dissected away. The interior of the joint is now exposed, and the ends of the bones can be dealt with according to the primary origin and extent of the disease. If the whole of the joint is diseased, the articular ends, including both malleoli, are removed, and one or two posterior incisions made so as to expose and enable extirpation of the rest of the synovial sac. If only one posterior incision is necessary, this should be carried along the outer side of the tendo Achillis. After the removal of the diseased parts of the joint the anterior incisions are sutured, whilst the posterior are left open for drainage. Bruns has made this operation fourteen times with very good immediate and remote results, and recommends it strongly as the one which affords freest exposure of the diseased joint, and at the same time makes it unnecessary to injure important parts.

Results.—The functional results of arthrectomy and resection of ankle-joint, when the operation is limited to removal of diseased tissue, are usually satisfactory.

Erasmus ("Die Arthrectomien des Fussgelenkes nach König." *Deutsche Med. Wochenschrift*, p. 349, 1885) reports eleven cases of arthrectomy of the ankle-joint made by Riedel in three years. The patients were children from 1 to 10 years of age, and two girls 17 and 26 years old. In two cases the disease was limited to the synovial membrane. The patients, as a rule, regain good use of limb with movable joint, and the shortening is slight.

Tubercular sequestra in two cases and in six cases granulating foci in bone. Eight of the cases had completely recovered at the time the report was made, one died seven weeks after

operation of tubercular meningitis, and two of the cases were progressing in a satisfactory manner. In three cases no shortening was present; in two cases the shortening amounted to one centimetre, once one and a half centimetres, and twice two centimetres. A fair degree of mobility of joint existed in all of the cases, when a sufficient time had elapsed, and was expected in the others. No mechanical support was worn by any of them. Boeckel made four synovectomies, in children 2 to 4 years of age, with permanent result and good use of limb five to seven years after operation. The functional results after resection and arthrectomy of the ankle-joint are, as a rule, satisfactory. The shortening, if any, is slight, and the range of motion all that could be wished, while the limb is strong enough to enable the patient to walk great distances without the aid of mechanical support. Bornitz ("Ueber die Arthrektomie des Fussgelenkes nach dem König'schen verfahren und über eine neue Modifikation desselben." Bruns, *Beiträge zur klin. Chirurgie*, Bd. viii) reports fifteen arthrectomies of the ankle-joint for tuberculosis, of which in five cases the operation was followed by local recurrence. In the remaining ten cases the operation proved a perfect success; all of the patients recovered with a useful limb, and in some of them the functional result was almost perfect.

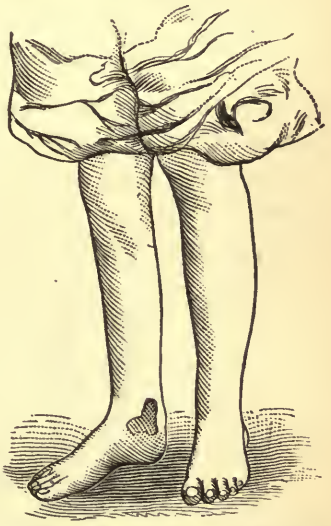

FIG. 103.—EXCISION OF ANKLE-JOINT IN CHILD SEVERAL MONTHS AFTER OPERATION.

Tarsus.—Until quite recently, tubercular affections of the tarsus, as a rule, were subjected to amputation. At the present time conservative surgery is applied to this part of the foot to the same extent as in the treatment of tuberculosis of other bones and joints.

Primary Seat of Disease.—Of the tarsal bones the os calcis is most frequently attacked; next the proximal end of the first metatarsal bone; the cuboid comes next; then the astragalus, and the scaphoid and cuneiform last. In the os calcis

FIG. 104.—EXCISION OF THE OS CALCIS.

cheesy foci are more frequent than the necrotic form. In connection with tubercular disease of one or more of the tarsal bones, osteoporosis of the remaining bones is a common occurrence.

Resection.—Ignipuncture and parenchymatous injections of

FIG. 105.—MIKULICZ-WLADIMIROFF'S OSTEOPLASTIC RESECTION OF THE TARSUS. INCISION THROUGH SOFT PARTS.

iodoform or balsam of Peru can be done, with a fair hope of success, in all early cases of tarsal tuberculosis. If the disease is limited to the os calcis and does not yield to conservative treatment, or has resulted in the formation of fistulous openings,

this bone should be removed in its entirety by an incision extending, from a point below the attachment of the tendo Achillis, along the upper margin of the sole of the foot, on the fibular side, the whole length of the bone.

If the disease involve both the os calcis and astragalus, both of these bones can be removed through a similar incision, under the same circumstances. Functional result after either of these operations is satisfactory. In extensive disease of the posterior part of the tarsus as far back as the ankle, the anterior part of the foot can be preserved by Mikulicz-Wladimiroff's osteoplastic resection of the ankle, with good prospects of obtaining a useful limb.

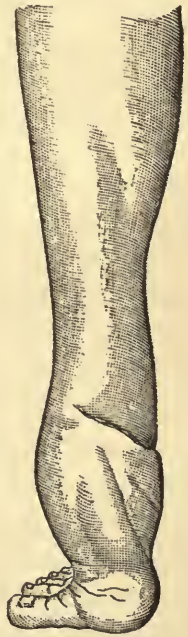

FIG. 107.—POSITION OF FOOT AND TOES AFTER THIS OPERATION.

Chobaut ("Contribution à la Chirurgie du pied. De la tarsectomie antérieure totale et partielle dans les cas pathologiques." Paris, 1889) has given a description of Ollier's method of performing anterior tarsectomy. Access to the diseased bones is secured by this operation through four incisions,—four to five centimetres in length,—made over the dorsum and in the long axis of the foot, and in such a manner as to prevent injury to important tendons, vessels, and nerves. The first incision is commenced about one centimetre behind the tuberosity of the os navicularis and carried to the inner border of the base of the first metatarsal

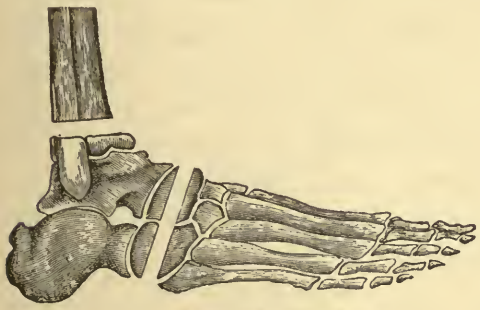

FIG. 106.—BONE SECTIONS.

bone. The tendon of the tibialis anticus is drawn upward and outward so as to keep it out of the line of incision. The second incision follows the inner margin of the first tendon of the common extensors of the toes and extends to the first interosseous space of the metatarsus, and passes along the outer margin of the first cuneiform bone. In this manner injury to the dorsal artery, which runs along the outer border of the tendon, is avoided. The third incision reaches from the prominence of the astragalus, which can be felt if the foot is abducted to the fourth interosseous space of the metatarsus. It passes between the third and fourth tendons of the common extensor muscle. This incision is on a level with the junction of the third cuneiform bone and the cuboid. The fourth incision finally extends, in the adult, two centimetres from the anterior border of the external malleolus and ends at the tuberosity of the fifth metatarsal bone; it extends along the upper and inner margin of the peronei muscles. In removing the diseased tarsal bones, Ollier usually commences with the scaphoid and first cuneiform, occasionally with the cuboid, if this is more extensively diseased, and consequently can be extracted with greater ease. Wherever it is found necessary, the anterior surface of the calcaneous and astragalus, as well as tarsal ends of the metatarsal bones, are likewise removed. Resection of the tarsal bones in front of the ankle-joint must be done through an anterior or long lateral incision.

Obalinski (*Centralblatt f. Chirurgie*, October 25, 1890) describes a new method of incision for resection of diseased portions of the tarsus. The two outer toes being taken by the surgeon, and the three inner by his assistant, on the right foot, and *vice versâ* on the left, the knife is carried between the third and fourth metatarsal bones, and then between the cuboid on the outer side and the third cuneiform and scaphoid on the inner side, as far as the astragalus and os calcis. The middle tarsal joint is now opened, and the lateral halves of the foot are drawn widely apart almost to a right angle to its long axis on

either side. After the removal of any diseased portions of bone, other parts of the foot are exposed to view, so that all the bones of the tarsus and metatarsus may be seen and reached, and a thorough examination made for diseased tissue. After the bleeding has been arrested, the cavity of the wound is stuffed with iodoform gauze and the two portions of the foot are drawn together and kept in position by sutures.

Gritti ("Resectio Dorsalis Tarso-Metatarsea." *Annals of Surgery*, vol. ix, p. 233) has devised a new incision for the excision of the tarsal bones when the disease is located near or at the junction with the metatarsal bones. The operation is performed as follows: A transverse incision of the skin is made over the instep, somewhat above the base of the metatarsal bones; at each end of this an incision is carried, the one along the outer and the other along the inner border of the foot. These, when completed, should mark out the letter **H**. The two rectangular flaps are reflected and the bones exposed. The navicular and cuboid bones are sawn across, in a direction from the dorsum toward the plantar surface, and upon the same level. In the same manner the metatarsal bones are sawn through, and the parts to be removed loosened from their connections with the plantar surface of the foot; ligature of the anterior tibial artery will be necessary; the surfaces of the sawn bones are to be sutured, as well as the tendon of the extensor longus pollicis, and external wound closed. This operation differs in several details from the procedure devised by Bardenheuer ("Die Querexcision der Fusswurzel-Knochen." Von Dr. J. Schmidt. Mittheilungen aus dem Kölner Börrger hospital von Prof. Dr. Bardenheuer, 1886).

Believing that tuberculosis of the tarsus most frequently originates in or affects the five small bones at the root of the foot, Bardenheuer invariably extirpates all these bones in caries of the tarsus. He makes a transverse incision over the dorsum of the foot, from the bone of the first to that of the fifth metatarsal bone, or higher up, according to circumstances. The

tendons of the common, long, and extensor muscles of the toes, of the external interossei muscles, and, sometimes, that of the abductor digiti minimi are cut through, together with the smaller vessels and nerves. The entire flap having then been dissected up, parallel cuts are made through the entire bony portion of the foot with a saw, and at right angles to its axis, and thus a section is taken out of the middle of the foot including all of the diseased bones. The incisions are directed through the substance of the bone. After operation the front part of the foot is connected with the posterior portion only by the plantar soft tissues. The two portions are now approximated, and the skin sutured, or else, and preferably, tamponade with dry antiseptic gauze is done, and the parts united by secondary suturing after the surfaces are covered with granulations. In the seventeen cases of this operation, performed by Bardenheuer, recovery generally occurred without reaction. The anterior portion of the foot could be moved in two or three weeks, and the toes could be extended. In one month recovery was complete. The author believes that a new articulation is formed between the approximated bone surfaces. With the exception of three cases, where secondary resection became necessary, the operations were all successful.

Isler ("Ueber grosse atypische Resectionen am Fusse." *Deutsche Zeitsch. für Chirurgie*, B. xxxi, Heft 3 u. 4) has collected one hundred and forty-five cases of extensive atypical resection of the ankle, tarsus, and metatarsus from the practice of eighty-five different surgeons. Of this number fifteen died,—a mortality of 10.3 per cent. An excellent functional result was obtained in fifty-nine cases, a good result in thirty-nine, a fair result in eleven; the ultimate result remained undetermined in twelve, bad result in nine. Of the latter cases, it became necessary later to resort to amputation in seven. The best results were obtained in patients under 15 years of age. Kappeler recommends an inner and outer incision, preserving the tendons, nerves, and vessels as far as possible.

Ransohoff ("Tuberculous Disease of the Tarsus." *Medical News*, November 29, 1890) has tabulated thirty operations made for tarsal disease, and it is stated that, of this number, in fifteen évidement was done, of which but two were successful, and these were children. In six the curetting was followed by exacerbation of the previous conditions. Of twelve excisions, four were primary, and in three the operations were made before sinuses had formed. In these primary operations the repair was more rapid than in those in which curetting had previously been done. Four resections proved failures,—in three from recurrence of the disease and in the fourth from the uselessness of the foot. In two cases, patients aged 12 and 30 years, I removed all of the short bones of the foot for disease, and obtained a useful foot. In the older patient the lower end of the tibia answered an excellent purpose as a substitute for the heel, while the articulation which formed between its anterior surface and the base of the metatarsal bones was movable, enabling the patient to walk readily and gracefully. Boeckel made seventeen tarsectomies, and in all of them the operation proved successful. In one case he removed the os calcis and astragalus in a child 3 years old, who became a gardener, and when 18 years of age could walk sixteen to twenty kilometres a day with scarcely a limp, all movements of the foot being nearly normal.

Resection of Metatarso-Phalangeal Joint of Big Toe.—Peterson recommends ("Ueber Arthrectomie des ersten Mittelfuss-Zehen gelenks." *Archiv f. klin. Chirurgie*, B. xxxvii, S. 677), instead of the customary incision along the inner aspect of the joint, an incision between the first and second toes as far as the neck of the head of the metatarsal bone. The cut is made a little nearer the great toe. Both toes are now forcibly separated and the joint is opened. The soft tissues are separated anteriorly and posteriorly from both bones, without dividing any muscles or tendons. The farther the dissection is carried, the better the toe can be adducted; finally, the toe can

be bent inward to the extent that the end of it points backward, and the joint is opened in its entire extent, and can be dealt with according to the local conditions which are presented.

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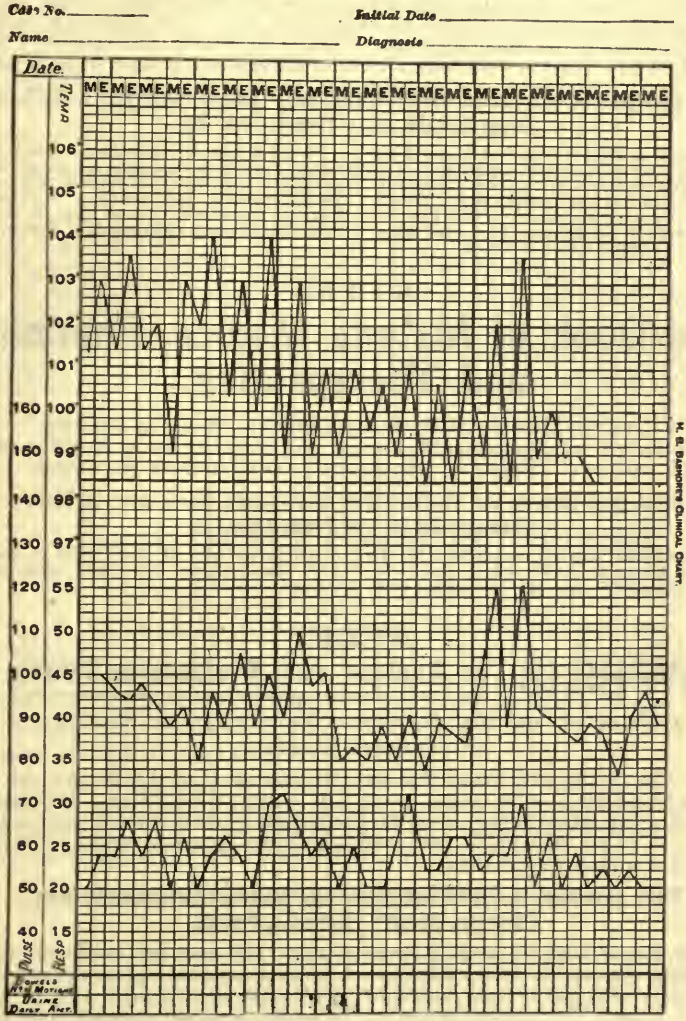

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